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ABSTRACT

The implications for higher education of the U.S. transformation from an industrial to an information society are discussed in six papers. Russell Edgerton provides an overview in "Entering the Information Society: An Introduction." In "The Computer: An Enabling Instrument," Louis Robinson considers the current era of the personalization of the information processing function, computers in colleges, computers as information processors, the technology of such machines, and the computer as a democratizing instrument. George Gerbner discusses the power of the mass media, especially television, as a prominent characteristic of the information society in "Liberal Education in the Information Age." Topics addressed by Ithiel de Sola Pool in "Academic Practices, Freedoms, and the New Technologies" include the following: the effect of communication technologies on academic practices and academic freedom, how centralized or decentralized the management of educational technology will be, and teaching with computers. In "The Library: Center of the Restructured University," Patricia Battin considers traditional roles and services of the librarian, new communication links, and six policy implications. Finally, Steven Muller's "The Post-Gutenberg University" discusses the nature of the challenge facing higher education. (SW)

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1983-84 • NUMBER 1

CURRENT ISSUES IN HIGHER EDUCATION

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Colleges Enter the Information Society

Russell Edgerton
Louis Robinson
George Gerbner
Ithiel de Sola Pool
Patricia Battin
Steven Muller

HE 016 948

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The *Current Issues in Higher Education* series brings members and subscribers a thematic set of briefing papers three to four times a year.

In previous years, the series was built exclusively around papers delivered at AAHE's National Conference on Higher Education. This particular issue continues in that tradition, carrying edited versions of papers from the March, 1983, National Conference.

Subsequent issues in the 1983-84 series will be more topical—written literacy and computer literacy are forthcoming topics—and will be built around papers collected from a variety of sources. Papers in the latter issues are selected and introduced by a guest editor and followed by an annotated bibliography on the topic prepared from the ERIC system.

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Louis Robinson

Louis Robinson is director of university relations for International Business Machines (IBM) Corporation. His presentation of an expanded version of this paper was well received at the 1983 National Conference on Higher Education which carried the theme "Colleges Enter the Information Society."

George Gerbner

George Gerbner is professor of communications and dean of the Annenberg School of Communications at the University of Pennsylvania. This paper was presented as his keynote address at the 1983 National Conference.

Ithiel de Sola Pool

Ithiel de Sola Pool is a Ruth and Arthur Sloan professor of political science at the Massachusetts Institute of Technology and director of MIT's research program on communications policy. He presented a version of this paper at the 1983 National Conference.

Patricia Battin

Patricia Battin is vice president and university librarian of Columbia University. She presented this paper at the 1983 AAHE National Conference.

Steven Muller

Steven Muller is president of The Johns Hopkins University and The Johns Hopkins Hospital. This is a revised version of the paper he presented at the closing plenary session of the 1983 AAHE National Conference.

An Introduction

Entering the Information Society

Russell Edgerton

This edition of *Current Issues in Higher Education* is organized around the proposition that the United States is in the midst of a profound transformation from an industrial to an information society. The articles in this monograph—all based on presentations delivered at AAHE's 1983 National Conference on Higher Education—illuminate some of the implications of this transformation for colleges and universities.

In the 1960s, social observers with wide-angle lenses began to realize that the industrial era—which had replaced the agricultural era—was coming to an end. But it was not clear what the salient characteristics of the new era would be. Daniel Bell coined the term "post-industrial society," defining the new era simply by what it was not. Alvin Toffler seemed even less precise in describing the new era as "the third wave."

In the meantime, economists began to argue that our economic base was shifting from the production of goods to the provision of services. The "services economy" seemed to provide a handle on at least a part of what was happening. Then, thanks to the pioneering work of Fritz Machlup, attention focused on the extent to which these services involved the production, processing, and distribution of knowledge and information. Inspired by Machlup, Marc Porat broke down the National Income Accounts in order to see what portions could be attributed, directly or indirectly, to information activities. In Porat's estimation, there was a primary information sector that produced information machines and sold information services as a commodity, and a secondary information sector that was engaged in information and knowledge handling. Porat's thesis, published in 1977 as *The Information Economy*, dramatized the extent to which the workforce has shifted in the past 100 years from farming to industry to information handling. (See Table) A few years later, the "information society" had become a popular cliche.

Although it may seem to be elusive and groping, the "information society" is a useful term. In planning the 1983 National Conference, we did not want to focus simply and narrowly on the use of information technologies for educational purposes. We also wanted to consider how the computer and telecommunications revolutions are transforming the United States into a new kind of society, and how this shift affects everything colleges and universities do, including what many feel to be the heart of the enterprise, the substance of liberal learning. Our theme, "Colleges Enter the Information Society," seemed to fit this bill.

The articles in this monograph address these wider issues. The lead article by Louis Robinson, director of university relations at IBM, sets the stage. The computer revolution is the central dynamic propelling us into the new society. Robinson provides a marvelous feel for the computer's potential. It is, he argues, an enabling device whose potential is limited only by our imagination.

The other pieces connect explosive changes in society to particular effects on colleges and universities. In sorting through these changes, it is useful to distinguish between the changes that alter the purposes of colleges and universities and changes that alter the ways colleges and universities do business.

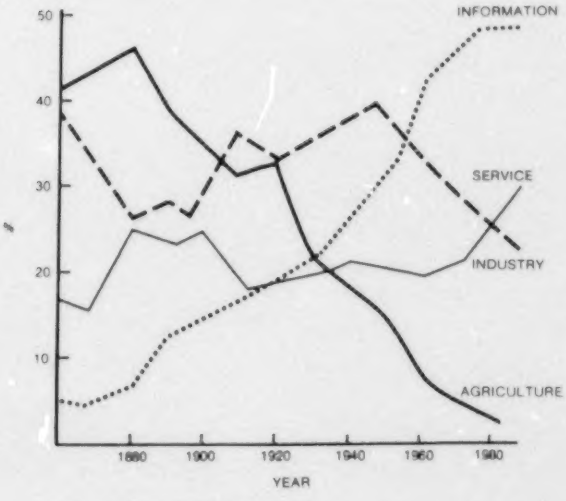
As to purposes, most recent discussion has focused on how colleges and universities should regear their curricula to respond to the demands of

Russell Edgerton is president of the American Association for Higher Education.

the new high-tech economy. A great deal of attention has been given to how we can increase the supply of talented scientists and engineers. A related issue concerns what colleges and universities should do to help the non-scientist and engineer become sufficiently "literate" in computers, science, and technology, to function as citizens and complete human beings in a technological society.

In the context of today's discussion about purposes, George Gerbner's article offers a refreshing counterpoint. Gerbner calls our attention to the fact that changes are occuring in many important arenas of life beyond the workplace. One of the prominent characteristics of the information society is the power of the mass media, especially television. Television is now the principle vehicle by which culture is passed from generation to generation. It "dominates the cultivation of common consciousness as local parochial culture did before the print era." In Gerbner's view, the purpose of liberal education is not to transmit some immutable body of knowledge, but to liberate people from whatever it is that enslaves their minds and spirits. How to develop in students a critical and analytical stance toward the tyranny of mass-produced culture becomes, then, a compelling agenda for liberal education.

The Growth of Information Occupations
U.S. Work Force 1860-1980



Source: Poret, *The Information Economy*, Vol. 1, P. 121.

The articles by Ithiel de Sola Pool and Patricia Battin address the implications of the new technologies on the way colleges and universities conduct business. Pool asks the question, how will the new communication technologies affect academic practices, especially academic freedom? His cogent argument that, in the long run, technology will enhance the autonomy of the scholar and foster the individualization of instruction is, in my view, the most significant statement on this subject that exists today.

No area of college/university operations is more affected by the new technology than the library. As Patricia Battin points out, libraries are establishments built around books. But the new technologies now allow scholars and students to access information without the need for books. Whereas Pool sees libraries losing functions over time as individuals seek out information from primary sources, Battin sees the possibility of an alternative role for libraries. If, she points out, libraries would move beyond the book and into the new communications world, libraries could become the center of the restructured university.

The final article by Steven Muller serves to dramatize the nature of the challenge facing higher education. Muller reminds us that we are not just looking at new technologies. We are also facing new types of students, new competitors, and whole new modes of learning. Together, these add up to an environment that is changing radically. Coming from the president of Johns Hopkins, a bastion for the ancient regime, Muller's statement confirms just how profound a transformation we are in.

The Computer: An Enabling Instrument

Louis Robinson

Each morning on Seventh Avenue in New York City in the heart of the garment district, an employee comes to work, puts on his white work coat, and steps up to his work table. He unrolls the bolt of cloth he is to work on that morning. After he smooths the cloth out on the table, he examines it to see if there are any imperfections in the cloth. Hovering over this table is a device that looks a little bit like the movable X-ray machine that you see in your doctor's office.

In fact, it is very much like that because it has in it a flashlight bulb that casts a cross-hair down on the cloth. Now the employee, in examining the cloth, sees an imperfection. He turns a few dials, and this machine, which is cantilevered over the table, moves automatically until the cross-hair shines directly onto the imperfection. Then he presses a button on the side of the machine and the computing machine that is connected to the device memorizes the geometric location of the imperfection.

Then he sees another imperfection, and he turns the dial until the cross-hairs shine down on it. He presses the button, and the machine memorizes its location. When he feels he has identified all of the imperfections in the cloth, he looks at the order form he has, and he sees he's being asked to cut, say, a man's size 40, regular suit. He keys that information into the system.

All the rules and formulas and algorithms for taking the standard man's suit pattern and adjusting it to whatever the order is resides in the memory of the machine, so it calculates what the pattern ought to be. Then the computing machine lays the pattern out on that cloth, guaranteeing that the pattern never intersects any of the known imperfections in the cloth that the employee has already identified to the machine and allowing for the proper matching on the cloth. The system insures that the minimum length of the bolt of cloth is used in the process. When that is done, the employee presses a button, and a laser beam comes out of the device and it cuts the cloth.

When that man goes home at night, and someone asks him what he does for a living, he says, "I'm a tailor."

And he *is* a tailor. In very dramatic ways, through the information technologies we use in our institutions, business, industry, government, and education, we have started to change the way people work, the way people live, their vocations and avocations, the way they think and, in many cases, speak. It becomes a habit for people to attribute to these machines causal relationships or responsibility for events. We start to blame them for things we think they do to us, forgetting the role of the person who uses or programs the system in the first place.

It is the perceptions we hold as a society and individually that often tell us a great deal about the direction of a technology.

A Glance Backward

Thinking back some thirty years to when I first got into computer science work, it occurred to me that if someone had asked me then what were the two biggest problems we faced, I think I would have said that they were these:

First, while we were delivering the very earliest machines to national laboratories doing mostly atomic energy work and some aerospace companies and high technology laboratories, *we worried about whether the machines would work*. Now, how can

Louis Robinson

you worry about whether a machine will work when you are already delivering it to customers?

We worried about it because the engineers would tell us that the machine consisted of 18,000 tubes, and they would describe the mean-time to failure of the average tube. It did not stress one's statistical background to calculate how often such a machine should fail; it was predicted that it would fail several times a day, and, in fact, it did.

How could people use these machines if they failed several times a day? Well, one has to think back on how they were used then.

First of all, all failures were not catastrophic; many were intermittent. The machines were being used to solve mathematical problems, particularly differential equations, by iterative techniques. Those techniques meant that the program used caused the machine to approximate a solution to the problem; by executing the appropriate mathematical rule or algorithm the system only assured that the method converged in the direction of a solution to the problem. If, in the course of as many as millions of iterations, something went wrong and you got an extraneous blip in the machine that caused some number to be not quite right, it might not matter because it was a self-correcting procedure, and with the next iteration, the system would continue to converge, in a general case, towards a solution.

So, a very large class of errors did not seem to affect the applicability of this machine to that kind of use. The problems being studied were experimental and, in the best sense, people could only make approximations to those problems and were looking only for general insight into the direction that the answers would point them. Precision took on a subjective meaning.

We wondered if the machines could ever be effective in industry in general, in insurance companies, the airlines, medicine, or government where things had to be calculated precisely down to the last penny and where approximations would hardly do.

The second thing we worried about was *whether there would be enough programmers*. Now, there were obviously programmers around to run those early machines. They were physicists and engineers and mathematicians who, in programming machines, had to take into account more than just programming logic to make sure that the sequence of instructions given the machine bore a logical relationship to the problem solution that they were trying to implement. In addition, they had to worry about the timing of the circuits in the machine because the machine was dependent, to a large extent, upon the interdependencies of the various circuits and their timings. So the sequence alone was not sufficient; one had to be sure that enough time was allowed for each circuit to execute its function in a proper fashion before going on to the next step.

Now, when I say we worried about whether there would be enough programmers around, we understood that physicists and engineers and mathematicians rather enjoyed that challenge in national laboratories and aerospace laboratories. But it was not clear that there would be people around to write the programs needed for insurance companies, airlines, banks, and hospitals. So we worried about whether there would be anyone around to write the necessary programs.

Well, today one does not worry about either of those two questions as a practical matter. One does not exhibit much concern about the workability of the machines. Information systems today are very reliable—some 10,000 times more reliable than the early machines. In fact, in contemporary machines, particularly large ones like the 3081, ninety five percent of all circuits are already hardware-checked for failure. While we never expect to be able to build machines that never fail, it is quite reasonable to expect that we can build machines that, when they do fail, can detect that they have failed and correct the problem. We already have machines that are reliable enough to work regularly and to produce the answers we want.

We do not worry very much about programmers anymore, either. There are hundreds of thousands of machines in the world and there are clearly programmers around to run those machines; otherwise they wouldn't be used. We would always like to have more programmers, better quality programmers, programmers trained in different disciplines, but there are plenty of programmers around to run the existing machines. So, if we do not have to worry about the workability of the machines or the programmers, what is left to worry about?

As far back as we go we see the elements of an attempt by people to build automatic devices to process their information. And everywhere we see such efforts, we see evidence of people's lack of understanding, dislike, and fear of such devices.

I suggest to you that what is left to worry about is much more substantive than those early problems and that is: what is the proper applicability of these technologies to the kinds of problems that affect the way we live and our quality of life?

Looking to the Future

Foreseeing trends in the future for the next ten or twenty years in information processing is hard to do. The fact that, by some accident, some few of us happen to work in research or advanced technology does not mean we have a better crystal ball than anybody else. Your best guess about what might happen in information processing in the next one or two decades is as good as anybody else's.

Technologists historically have been very poor forecasters of the longer term implications of their own work. When I was a youngster in New England, one of my favorite heroes (there was a time when we used to have heroes in the U.S.; we hardly have any more) was an engineer named Dr. Lee DeForest. He invented the vacuum tube which was used in early radios and, subsequently, in televisions and other electronic devices. Back in 1926, DeForest was taken to a laboratory where he witnessed the use of his invention to build the prototype of a working black-and-white sending and receiving television system.

"While, theoretically and technically, television may be feasible," he wrote, "commercially and financially, I consider it an impossibility, a development of which we need waste little time dreaming."

That from the man who started the whole thing!

So, it is never easy to have a good perception of how things are going to be. The French poet Antoine de Saint-Exupery once observed: "As for the future, your task is not to foresee but to enable."

An Enabling Instrument

The computer is an enabling instrument. It is an instrument that makes it possible for people to do what is so basic to the human enterprise: to process information in increasingly efficient and different ways. But therein lies the challenge—the challenge of learning to live with change.

It is all too easy to say that computers are never going to be much more modern than they are now. We may believe we've seen the ultimate, but what we've perceived over the years and what we can envision today is a guarantee of change. There *will* be better components; denser, faster, and more reliable circuits; faster printers and display devices; etc. There will be breakthroughs in the programming sciences; in how we talk to machines; in new solutions to business and institutional problems.

One of the prime reasons people fear technology is that they do not understand it. Intensive training is necessary before a person can talk to a machine. This has helped create a fear of technology and, as a result, probably an arm's-length dislike and rejection of it.

We might think that the phenomenon is new. We might believe that, at best, such concerns start with the invention of the ENIAC of the University of Pennsylvania in 1946. That is not the case. It is a response to automated devices and information processing tools that goes back as far as the very beginning of recorded history of human life on our planet.

The history of our society constantly provides evidence of our need and desire to develop better methods to record, communicate, and process information. The earliest cave man drawings can be viewed as attempts to transcribe and communicate important ideas. When the cave men left their caves, they built monuments, such as Stonehenge, which we now believe were designed, at least in part, to process astronomical information.

Our museums contain the ancient notched sticks used to record information. Among the oldest artifacts in the British Museum are the ancient knotted strings the Egyptians used to measure the pyramids. They were information processing tools. While very crude by modern standards, this was an appropriate way to solve the problems that had to be solved in those days. Certainly Gutenberg's invention of movable type is yet another step in the process. As far back as we go we see the elements of an attempt by people to build auto-

matic devices to process their information. And everywhere we see such efforts, we see evidence of people's lack of understanding, dislike, and fear of such devices.

The old Eastern European legend of Golem is the story of an inanimate object which comes to life when the secret name of God is whispered in its ear. Then it runs amuck and has to be destroyed by the society in order to set things right. We learn from that legend that robots and automatic devices are terrible things.

When Norbert Wienter, the great contributor to cybernetics and information science at M.I.T., wrote his memoirs, he chose to title his autobiography "God and Golem," to put into juxtaposition what he thought were the two opposite extremes of his life experience—the ethical and technological.

In the legend of St. Thomas Aquinas, there is a story about St. Thomas as a very young man going to the home of his teacher, Albertus Magnus. Albertus Magnus had built a robot which opened the front door and inquired as to the business of the visitor when somebody approached the house. When St. Thomas saw this robot for the first time he took the staff he carried with him and destroyed the robot.

We know the purpose of legends. They teach us things. We know, of course, that St. Thomas is a good man. He is a man of God and does exactly the right thing. Namely, he destroys the robot because robots are evil.

One of the great inventions of the industrial revolution was Joseph Marie Jacquard's invention of the automatic loom that weaves patterned cloth. He invented the loom in 1801 and by 1812 there were eleven thousand Jacquard looms in France. It made France, for the moment, the world's technological center for patterned, woven cloth. Other weavers, however, did not like the device very much and they rebelled against it in a habit peculiar to the French. When no one was looking, they would take off a shoe and throw it into the Jacquard loom. Now, if you have never seen a Jacquard loom, it was a delicate machine that did not take much more than a shoe to destroy it. The French word for shoe is "sabot;" the word "sabotage" enters our language because of that practice and the revulsion that people sometimes have to new technologies when they do not understand or perceive what will happen because of their use.

The first science fiction author to suggest that high technology can be used to improve the human condition was Dr. Isaac Asimov. Dr. Asimov postulated in his early science fiction books what are now sometimes called the Asimov laws of robotics. These laws about the basic design of robots were first stated in his story *Runaround*. They are: 1) A robot may not injure a human being or, through inaction, allow a human being to come to harm; 2) A robot must obey the orders given by human beings except where such orders would conflict with the first law; and 3) A robot must protect its own existence as long as such protection does not conflict with the first two laws.

Of course, Asimov's ideas have done a great deal to change the nature of robot stories in modern science fiction. If we take those three laws together they represent a thesis of hope, application, expectation, and the good and proper use of technology for valuable social purposes.

It is true that the long-term implications of high technology often are hidden from our view. It seems to me that it suggests some caution in interpreting, both favorably and unfavorably, what the implications of that technology may be. I think the burden for some of that interpretation may fall to those who are in our educational institutions to spend more time thinking about some of those longer term social implications.

It is difficult to view the trends and directions in technology separate from the phenomenon of the social acceptance of that technology. The social acceptance and use of the technology is as much a part of what the technology is and what it will mean to us as anything we can review relative to the memories, printers, and other components of the information system.

In order to discuss where we are and what kinds of future directions are evident in information science technology, we need a benchmark against which we can measure ourselves during the next decade or two. I suggest that one such benchmark is to start with where we are today in our information processing capability in this industry.

The Information Era

We are in an era of the personalization of the information processing function. We see computers and terminals at airline reservation counters, automobile reservation counters, brokers' desks, bank teller windows, department store purchase areas, supermarket check-out counters, and plant and process data acquisition stations. The interactive use of terminals is evident today in education, medicine, and many other institutions.

Let us take this image of the availability of the information processing capability to clerks, business managers, researchers, scientists, educators, and others and extrapolate to the broad universal availability of computers and terminals for all of us. Imagine a time when it will be as unlikely for you to see someone working without a computer terminal on their desk as it is unlikely to see someone working without a telephone on their desk.

It is the perceptions we hold as a society and individually that often tell us a great deal about the direction of a technology.

This possibility is not a far-fetched image when you consider that the SHARE report, "Data Processing in 1980-85," suggested that by the end of the decade, 70 percent of everybody employed in the labor force in the United States will have some knowledge of how a computer works just to be able to hold their jobs. Also consider the Department of Labor statistics that over 50 percent of everyone now employed is in an information activity.

In the United States today, there is a computer terminal for every 48 jobholders, including nurses, air traffic controllers, newspaper reporters, stockbrokers, and accountants. In a company like IBM, there is one terminal installed for about every 4.8 employees. We have some laboratories where there is one terminal installed for every employee. In some institutions, such as the insurance industry, there is already one terminal for every two employees and it is likely to be one for one soon. The estimate in the industry is that by 1986 there will be one terminal installed in North America for every ten employed people. What manner of research does this opportunity generate within IBM?

Computers in Colleges

Our work in IBM involves a very close liaison to universities around the world. We have some 380 different joint-study contracts with some 120 different universities in North America. I cannot possibly enumerate everything that is going on, but I do want to describe, in general terms, some of the implications of what I see and give a few examples which I think are more or less generic of the kind of work that is being done.

One such study is being executed jointly with the University of Chicago and the University of Wisconsin. There are similar studies going on at many other universities in the U.S., Canada, and Europe. The study has to do with automating the university library.

When we say we are going to automate a library, it sounds like we are going to put what was on those old 3x5 index cards into the electronic memory of a computer and then be able to look up information on a screen. Well, we are going to do that. However, there was not very much information on that 3x5 card—just the name of the book, title, author, number of pages, and publisher. We will need more information than that to do a substantive search, so the information of the figurative 3x5 card in the memory of the machine will contain a lot more indicative information on the content of the book, in the spirit of key word and context and other techniques, that are now used in information processing.

That retrieval program is only one of forty-five programs that we are trying to write. When we work with librarians, we discover that while, even for them, the first thought that comes to mind is automating the search, it is not the last thought. It is equally important to automate a whole variety of other problems that beset modern libraries, for example, maintaining patron lists and keeping track of who has authorization to buy books, order books, reserve books, put books on

the rare book shelf, get multiple copies of books, and assign books to classes.

There is also the problem of keeping track of the location of books. If you run across a text book whose title is something like "A Computer Program for LaPlace Transforms in Microbiology," in the old days (if you had that book), it would go in the central library. But today there are no central libraries on most campuses; rather, there are distributed libraries—there's a microbiological library and a mathematics library and a computer science library. So where do you put that book? Typically, such a book is placed into the library by the person who happened to order it. If the microbiologist ordered it, he gets the book. But if you are doing a study in computer science, some of the students in computer science probably would have difficulty in locating such a book in the microbiological library.

The problem of keeping track of the whereabouts of the book can, of course, be addressed by a computer system. So, when you are finished listing all of the problems associated with managing a library, you may have described 45 programs you would like to write. That is what we are trying to do.

Now, what is the goal of this study? I believe the ultimate goal is to have a student sitting in front of a personal computer in his or her dormitory room at the end of a coax cable. Let's assume that student is at the University of Chicago looking something up—let's say books on Byzantine art—and does not find the references that he or she is looking for. The student presses a single button and is automatically searching the University of Wisconsin Library. There is no requirement that the student have knowledge of satellites, communication theory, computer languages, operating systems, and communications protocol. There is even discussion at the U.N. about putting up an international satellite so that the same student, in a sense, can press yet one more button and search the Oxford Library or the Toronto Library, or any other library.

There is more to just looking things up, however. It would really be nice to get to the information itself, not just its description. One would like to put the books themselves in electronic memory.

If you think today about putting a textbook into electronic memory, the method that occurs to most people is to have a clerk sit there and key it into the system. At contemporary labor costs here in North America, it would cost about $400 to key in a typical textbook. That's a very good reason for not doing it—it's very expensive.

However, optical character recognition equipment is available that can scan that book with an enormously high reliability and read the book into the memory of the machine at a cost of $13 per book. That's less than the cost of most books alone. So it becomes at least feasible to think in terms of reading the books into the memory of computer systems.

Such an experiment would create a demand for a very large memory. Throughout the industry, we have devices called "mass storage devices." The IBM Mass Storage device, for example, has a memory capacity of 35 billion characters; that's the smallest version. The largest version has a memory capacity of 472 billion characters. To give you a feeling for how much information that is—take an encyclopedia, like Encyclopedia Britannica (30 volumes, 800 pages per volume), and assume that there is no white space and no photographs. The total character count of the encyclopedia is 160 million characters. The smallest version of this memory device that is marketed is 35 *billion* characters. So, you can get a lot of information into it; in fact, if you load it up, you can get the equivalent of 200,000 volumes of information in the memory of the machine.

The machine rents for about $20,000. That's 10¢ per book, per month, to store it electronically. A few years ago that sounded like an awful lot of money. But with inflation, the cost of real estate, steel shelves, and personnel, it is at least an interesting enough number to think seriously about what it might mean in the long term.

If you look to more advanced technologies, for example optical discs (sometimes called laser discs or video discs), there is a memory capacity of 1010 bits to the side on a video disc today. If we pack that information with character information, we can put the equivalent of 3,200 volumes of information onto two sides of a single disc. Now, it may not be the 3,200 volumes you want—it's someone else's idea of the 3,200 volumes you ought to read—but if you get enough of the discs,

then all the volumes of books or customer records or manufacturing records will be available. That disc retails today for $20. The reader for that disc retails over the counter for $750. So it becomes quite feasible to store very large amounts of information.

There are several such technologies. In silicon technology we saw memory cells packed on a single silicon chip rise from 1,000 to 64,000 bits during the 1970s. In an experimental IBM silicon chip, one sixteenth of an inch square, we can pack 4,000 logic circuits. Other experiments have shown that such chips can contain 10,000 logic switches or 250,000 bits of memory. In another development, 288,000 bits of memory were designed onto a single chip.

In bubble memory technology, using garnet material made of an aluminum-chromium-copper compound, we can create in our laboratories the equivalent of a memory of a hundred million bits on a square inch of material. That is roughly the equivalent of putting all of the Manhattan telephone directory on something the physical size of a postage stamp.

In order to build such a memory technology we draw circuit logic on the substrate with lines about one micron wide. A micron is one twenty-five thousandth of an inch. A human hair is about 40 microns wide. That width is close enough to the wave length of light that in a sense we cannot draw such lines with conventional light-dependent instrumentation. Instead, we must use technologies that depend on shorter wave length signals such as X-ray lithographic methods.

The availability of such a memory technology has made more meaningful the systems and programming research now going on in many laboratories in office automation, electronic mail, and text editing systems. This is not so much because such studies weren't formulatable ten or even twenty years ago. But only now are the variety of technologies becoming available in laboratories that gives us assurance of the ultimate implementability of such systems. Large local reliable and inexpensive memories are important for such systems.

Consider what happens when we then try to manipulate the information stored or create new information files.

Computers: Information Processors

When talking about computers, what comes to mind first and foremost is a machine that does arithmetic. Such usage characterized computers in their earliest days. The use by computer scientists of measurement devices such as hardware and software monitors has demonstrated to us that the computing machine is doing arithmetic less than five percent of the time. The rest of the time it is moving the information about in its memory and putting it in different juxtapositions.

The results of that process are perceived by us as information processing. Certainly, in our own thinking and processing of information, we find ourselves doing arithmetic for an even smaller percentage of time. As a result, much of the research we are engaged in has to do in part with arithmetic and algorithmic approaches and mathematical techniques, but it also relates substantially with the generic area of information manipulation in the style of text editing and electronic mail transfer.

We start by considering automating a library and, before we know it, we discover that we must consider a broader area of information processing. That seems to be the character of systems work.

One such project has to do with a spelling corrector. One of IBM's scientists, Dr. Walter S. Rosenbaum, has built an experimental spelling corrector with a vocabulary of 130,000 words. That vocabulary represents both English and British spellings for the words where they differ. That is a very large vocabulary. An average college graduate probably has a vocabulary of about 10,000 words. One of the landmark books in our language, James Joyce's *Ulysses,* represents a vocabulary of about 30,000 words. This system includes 105,000 medical terms, 22,000 legal terms, business terms, etc.

If one types a simple word like "there," t-h-e-r-e, and it come out h-t-e-r-e, the system would recognize that there is no such word in the English language. The system can have enough algorithmic capability to analyze the error and suggest to the user the most probable correct spelling.

But it does more than that. For example, assume one typed in the phrase, "There are papers on the platform," and spelled t-h-e-i-r, instead of t-h-e-r-e. The system would be capable of analyzing the phrase "their are" and indicate that in common usage it should read "there are."

But it does more than that. Let's say that one types the word "principle" spelled correctly. The system could indicate that this word is commonly confused with "principal." It can even provide a definition of each of those two words, so one can decide which spelling would be correct in context. Of course, it would do this for a wide variety of such homophones.

But it does more than that. If one types in phrases that are highly redundant or clumsy such as "There are a great deal of papers on that platform," the system could identify the phrase "a great deal of" and suggest its replacement by the more concise "many."

But it does more than that. The system can have a dictionary of synonyms which are graded according to the level of education of the potential reader. And, of course, such a system could handle automatic hyphenation, margin justification, and other aspects of text preparation.

We start by considering automating a library and, before we know it, we discover that we must consider a broader area of information processing. That seems to be the character of systems work. Almost every study in information science expands itself to become very global in its structure.

Another technological challenge is created by the use of those memories and the system itself. If we are going to do what we want to do on those systems—then we are going to expect those systems to execute a very large number of instructions.

Consider the airlines reservations application. You know that when you walk up to the airport reservation counter and inquire about a seat to another destination, the reservation clerk types in a few characters and seems to get a prompt response. We know that the clerk's terminal is communicating to some distant central computer. Under a CICS operating system, that central computer will execute about 250,000 instructions to send the appropriate response back to that clerk's terminal.

When we get our annual life insurance premium notice or a subscription reminder notice, those very simple documents give us the relatively straightforward information we need in order to respond. However, the central computer that prepares that reminder will execute 500,000 instructions in preparing the notice.

Now, in a more personal system, most inquiries we are likely to make represent a complicated question. We will expect the machine to execute many millions of instructions in preparing a response. That is not feasible today because we may not get the response that we want within the time constraints that normally apply in such a situation. But that problem is being solved.

The Technologies

Modern machines are built essentially out of nanosecond technology. The current technology of such machines switches in nanoseconds (billionths of a second). In some very expensive top-of-the-line systems, circuits switch in a few nanoseconds. In slower, less expensive machines, certain functions may take several thousands or tens of thousands of nanoseconds.

In general, however, the state of the art in current electronic technology is nanosecond technology. In about a billionth of a second that electrical signal travels nominally about a foot. Therefore, in building modern machines today, we have to put most of the circuits in such a machine within about one cubic foot of each other. And that is feasible. In the IBM 4300 series machines we put 704 circuits on a quarter of an inch silicon chip. If we put enough of those little chips together—we can get almost all the hundred thousand or so circuits of a contemporary machine within a cubic foot of space.

In an interactive demand environment, however, even faster systems may be required to provide the appropriate response time. Fortunately, there are much faster technologies in development in our laboratories.

Programming advances that simplify the user interface will characterize the decade of the eighties in computer science.

There is the field effect transistor technology (FET) which, using one micron line, can provide up to 10,000 logic gates per chip. There is also the faster bipolar technology.

Perhaps one of the most exciting technologies is cryogenic technology where circuits are imbedded in an environment close to absolute zero in temperature. That is 273 degrees below zero Centigrade or Celsius, and 459 degrees below zero Farenheit. At such temperatures, resistive properties of circuits seem to all but disappear and, by using the proper circuit logic, very fast switches can be created.

In recent experiments, switches which operate in several picoseconds have been built. A picosecond is a trillionth of a second and is to a second what a second is to 31,710 years. Now we are able to build experimental circuits which do things in a few picoseconds.

There are certainly some problems involved in such an experiment. While in current nanosecond technology we must be concerned with hundreds of thousands of circuits packed essentially within a foot of each other, in a picosecond system we must be able to pack all such circuits nominally within one hundredth of an inch of each other.

Another consideration is that systems are much too complicated to use today. Programming languages such as FORTRAN, COBOL, APL, BASIC and PASCAL and operating systems such as VM, MVS, UNIX, and others all represent interfaces to systems which are far too complicated for the most general use we might envision in the future.

Machines must become much less complicated to use. I believe that is happening. The driving force is the work in programming and systems advanced technology in laboratories around the world. Of special importance is the basic work in the field of artificial intelligence and the current developments in knowledge based systems. Knowledge based systems or expert systems are interactive and are built around data structures which can represent all the relevant problem domain facts and their interrelationships. Its interactive dialogue acts as an intelligent consultative system to the user. Such experimental systems already exist in a wide area of applications including the problem areas of medical diagnosis and treatment, in organic chemistry for the determination of molecular structures based upon spectrographic data, geology for mineral exploration, structural engineering, in the design of molecular genetic experiments, and in other areas.

Systems will be much easier to use in the future. Programming advances that simplify the user interface will characterize the decade of the eighties in computer science. We should expect to see a growing simplicity of the interface between the user and the complex systems that we build.

The individual's access to computer technology depends on that access being simple enough to be manageable by the average person. Information processing has certain inherent complexities. There is no way to wish those complexities away. But they can be handled either by the system or by the user.

Until now, a great portion of that complexity was handled by the user. But personalized computing demands have created a market demand that a great deal of that complexity be absorbed by the computing system itself, thus making access to the computer system easier for the user. As a result, a great deal of development and research effort is devoted to creating a better understanding of the information processing function and figuring how to most efficiently and economically build these required functions and capabilities into future products.

The most important change of all may be the social attitude toward information systems. The first advanced degree in computer science was granted in the United States in 1964. Now there are over 200 colleges which offer undergraduate degrees in computer science and over 80 colleges which offer graduate degrees. Three hundred thousand or more hobby computers are in use as well as millions of digital games and devices. Personal computers have been introduced into the marketplace. We are learning to understand the technology and its application as never before.

Whatever their field, people need—and generate—information; and that accounts in large part for the exploding need for information processing. In the early days, we expected people with problems to come to the machine. Today, we've learned that it is much more useful to bring the capability of information processing to the people.

The most important change of all may be the social attitudes toward information systems . . . We are learning to understand the technology and its application as never before.

The Democratizing Information Machines

In an important way, such machines are really fundamentally different from all the other inventions we've become familiar with. The difference tells us something about their ultimate usefulness. We intuitively think of all machines associated with the Industrial Revolution as being used only by the nations that have them. So, for example, it is reasonable to speculate that only the English, French, and Americans were candidates for building the Panama and Suez Canals because they, and maybe a few other nations, had the technical ability to solve the problems involved in building something as Herculean as a canal. Very naturally, the use of technology was almost always limited to those who had it.

But the computer is different. Once it exists anywhere, it exists everywhere. There are students in New York, Chicago, and Los Angeles sitting at terminals trying to understand genetic principles, agriculture irrigation techniques, causes of cancer, and world weather phenomena. There are also students sitting at terminals in Addis Ababa and Bangkok, often connected by satellite, using the same technology to study the same problems. It is possible that the great insight into the causes of cancer will be discovered by such a student in Bangkok or by another student in Los Angeles.

The information machine has a unique characteristic: It is a democratizing instrument. It has a great leveling effect in making the entire society "information-literate," and making information available to people where they need it and can use it. This seems to be tremendously important, and I am not sure that we as a society yet understand what the total implications may be of this information capability.

When Gutenberg invented movable type several hundred years ago, for example, the printed word was no longer restricted to the privileged. In a somewhat similar way, the computing machine has made all kinds of information accessible to people everywhere. That does not mean that everyone will necessarily have a machine, or will want or need one. It means that those who *do* have a need, who can benefit from its use, will have access to one where they work and, ultimately, where they live.

We see in specific cases great advances in information technology. These are not without their problems and challenges.

Universities in the United States are finding it increasingly difficult to fill the need for trained engineers and computer scientists, and there is growing concern about the future quality of U.S. engineering and science education. In many cases, professors and students alike are hampered by obsolete equipment for instruction and research, and by lack of contact with the technologies practiced in the most advanced industrial laboratories.

While the number of students entering undergraduate programs in engineering and computer science has been increasing steadily for a decade, the number who continue their studies to the doctoral level has declined drastically. This trend makes it unlikely that the estimated 2,000 faculty openings can be filled from the ranks of current graduate students. Unless universities can offer competitive career prospects and more relevant instruction and research opportunities for their faculty, U.S. engineering education is likely to deteriorate. The result could be a further decline in U.S. industrial productivity and the ability of this nation to compete on an international scale.

The leaders of our educational institutions are becoming gravely concerned about this crisis which has great long-term and short-term implications. Marvin Goldberger, president of the California Institute of Technology, said, "there are certain important areas of science and engineering in which I believe we are not training enough young people. For example, in the U.S. currently, we are granting fewer doctorates in computer science than we were ten years ago." John Jamrich, president of Northern Michigan University at Marquette, said, "we need curricular and program modifications to respond to the dynamics of society and our growing technology."

Industry is dependent upon universities. Demand for graduate engineers exceeds supply; and fluctuations in government funding, for both education and research, threaten to undermine the skills and knowledge on which industry builds for a future of growing international competition. As

a result of these considerations, there is a growing interest in university-industry cooperation.

Taking Off the Blinders

As we've seen in the case of the vacuum tube and the transistor, there will always be skeptics where something new is concerned. Winston Churchill was a young man on a tour of duty in India when the X-ray was discovered. He read about it in the Indian press and wrote a letter home, which appears in the first volume of his memoirs. In it, he feared that this X-ray would spell an end to all human privacy because it could see through walls and clothing. He and his friends were so taken with this fear, they created a ditty that went something like this: "What a terrible thing, an 'orrible thing, is the new photography."

No one today would think of the X-ray as a threat to privacy. First impressions may not be correct.

Many people say that technology and computers invade our privacy, are dehumanizing, and will result in everyone becoming a number. I disagree. Society will take the proper steps to protect itself from any misuse of information machines. There already exists much legislation pointing in this direction. Dr. Edwin Land of the Polaroid Corporation observed that "any worthwhile invention must be startling, unexpected, and must come to a world that is not prepared for it."

The challenge we face is to learn to live with the fact that we will not be able to predict precisely what will happen in technology. Change will occur. Opportunities for application of that changing technology will occur. We can only be guided by humanitarian principles. Albert Einstein counseled "the concern for man and his destiny must always be the chief interest of all technical effort."

I believe that one day we will look back and say: Why did we worry? Didn't anyone realize that the thing we were worrying about really was a machine that would elevate humankind to a new plateau of intelligence?

We will recognize the opportunities represented by information processing technology. We will recognize that there will be a dramatic change in the ways we apply information technology. We will be there. We will have to know how to design it, build it, apply it, use it in our institutions, and teach it to our students. And yet we will have to face that challenge with the knowledge that we cannot predict today precisely how that change will manifest itself tomorrow. It is in the ignorance of what that change is that we will have to work.

I think the total potential of computers is only limited by our imagination. It's like giving an artist a palette that has an infinite number of colors, some of them invisible to the naked eye, like ultraviolet or X-rays. It's like giving a composer a set of musical notes and harmonics and chords, some of which have never been played before. It's like giving a poet an alphabet that is not limited to our letters and ideograms, that is virtually infinite in scope. It is a tool for the realization of ideas, and it carries with it a challenge for all of us.

Liberal Education in the Information Age

George Gerbner

The challenge of an information society in the telecommunications age is not only a challenge to education but also to the very process of humanization, the process that makes human beings out of Homo sapiens. In order to address that challenge, we need to take four steps:

- The first is to reflect on the unique and distinctive aspects of the humanization process.
- The second is to sketch how these aspects have shaped us and brought us to where we are.
- The third, is to identify the mission of a liberal education in that process.
- And the fourth is to try to develop a strategic conception of what we are up against in pursuing that mission.

Homo Sapiens: The Storytellers

Scottish patriot Andrew Fletcher once said that if he were permitted to write all the ballads, he need not care who makes the laws of a nation. Ballads, songs, tales, gestures, and images make up the unique design of the human environment. All animals react to things but humans act in a world of towering symbolic constructions that we call culture and includes art, science, law, religion, statecraft, and all other story-telling. Culture is that system of messages and images which regulates social relations; introduces us into roles of gender, age, class, vocation; gives us models of conformity and targets for rebellion; provides the range of personalities, temperaments, and mentalities said to be our "characteristics;" helps us rise to selfless acts of courage and sacrifice; and makes us accept (or even perpetrate) repression and slaughter of countless unknown people assigned to the appropriate categories of barbarians and other enemies. In other words, culture is that symbolic organization which socializes us and cultivates our fantasies about a world we do not experience directly. It is a system of stories and other artifacts, increasingly mass-produced, that mediates between existence and our consciousness of existence, and thereby helps shape both. As we encounter something new we hold it up to that fantasy. If it fits we call it real. Of course, that does not *make* it real; it only makes us behave as if it were. Therefore, it is all the more important to obtain accurate knowledge, to make warranted assertions, to develop ways of making statements that are relevant, valid, and true, to know what stories are and do, and most of all, to study how and on whose behalf we tell the stories that reflect, express, and shape our reality.

There are basically three kinds of stories. The first are stories about how things *work*. They illuminate our all-important but invisible network of relationships. They depict facts and people and set them in action so that the hidden dynamics of their interplay can be seen and explored. We call this type of story fiction, drama, poetry, etc. Only artful creations can incorporate a full and compelling human vision of how things really work.

The second are stories about what things *are*. They provide some verisimilitude to the larger mythology of how things work. They fill in that synthetic framework with selected facts—news, anecdotes, descriptions, explanations—to provide confirmation of a society's fantasy of its reality. Sometimes they undertake the difficult and risky task of challenging the mythology.

The third are stories of *value* and *choice*. They are as if to say: if this is how things work and what things are, then what should we do about them? What are our choices and what set of priorities

George Gerbner

should we follow? These are the exhortations, sermons, and instructions of all times. Today, most of them are called commercials. They present the styles of life to be desired and the choices to be made to attain them.

Three Cultural Epochs

These three kinds of stories have been woven together in different ways in different cultural epochs.

First, of course, is the preindustrial way of providing explanations of how things work, what things are, and what to do about them. The preindustrial way is face-to-face. It depends on memory and on ritual. It requires a great deal of repetition and the accumulation of a limited set of stories about the origin of the Universe, about the meaning of life, and the ways of proper conduct. The leaders of the tribe can reach and tell or interpret the stories for each small and stable total community.

Then comes the industrial transformation. The first machine is the printing press. The first industrial product stamping out standardized commodities is the book. That paves the way for the transformations to come. It breaks up the ritual and the face-to-face community. Printed stories are movable packages of consciousness that can be taken across hitherto impenetrable or closely guarded boundaries of time, space, language, religion, status. The book lifts people from their traditional moorings as the industrial revolution uproots them from their communities and cultures; it frees them from historic dependence on the ministrations and interpretations of their local chiefs and priests. The book can now be given to all who can read (a new class) to interpret as they wish.

Meanwhile people engage in long and costly struggles to tell stories and thus shape reality from their own points of view. The struggle is necessary for the formation of new identities and interests as the industrial age breaks the community into different and conflicting classes, mixes together religious and ethnic groups, and restructures the process of humanization heretofore confined by geography and relative stability. The way to achieve some control over the newly differentiating consciousness in a situation of unprecedented mobility and flux is to gain the right to select and write and publish stories (and thus create publics) stemming from radically different conceptions of reality existing in the same society. Notions of individuality and class consciousness are rooted in this era. The publication of different types of stories creates and cultivates mass publics—those loose aggregates of people who share some consciousness without ever meeting face-to-face. Mass publics are necessary for self-government and much of economic, educational, religious, and cultural life in the print-industrial epoch. Ever since the industrialization of story-telling, human consciousness is increasingly the product of a system of symbol mass-production.

Next comes the second industrial transformation. We enter the telecommunications era. Its mainstream is television, superimposed upon and reorganizing print-based culture. Television has its own characteristics. It is a centralized ritual, distant and pervasive and yet seemingly personal and face-to-face. It turns out and disseminates a limited number of stories about how things work, what they are, and what to do about them, along with the stars, scenes, social types, and other myths that make an otherwise diverse audience into a new kind of community: the modern mass public. In terms of its essential socializing functions, television is more like tribal religion than like any other selectively used medium preceeding it.

In terms of its essential socializing functions, television is more like tribal religion than any other selectively used medium preceeding it.

In the average American home, the television set is on 6 hours and 48 minutes a day. Most people do not watch television by the program but by the clock. The majority do not even decide what to watch until they turn on the set. The view-

Humans act in a world of towering symbolic constructions that we call culture and includes art, science, law, religion, statecraft, and all other story-telling.

ing pattern follows the style of life of the family. If that is rich and diverse, television has a lesser role in it. Otherwise, television practically monopolizes cultural participation and dominates the cultivation of common consciousness as local parochial culture did before the print era.

Liberating Education

Now to liberal education. I prefer to define it as "liberating education." I believe that its traditional role is to liberate the individual from an unwitting and unquestioning dependence on the traditional local and parochial cultural environment.

Liberation begins with putting the individual in touch with the great art, science, and philosophy of humankind. But if liberal education is liberation from dependence on an impoverished local and parochial cultural environment, then what role does it have today? Our cultural environment is anything but impoverished.

Television alone has abolished the old provincialism and parochialism. No one is out in the sticks anymore, culturally speaking. One can be very young or very old, far from the center of things, lying in a hospital or locked in a prison, and still live in the same cultural mainstream of the world of television as do most others more able, mobile, or fortunate.

For the first time in human history, the resident of the penthouse shares a great deal of the common culture with the inhabitant of the ghetto. The famous and the infamous, the celebrities and the criminals, the politicians, the spies, and the cops, and the parade of other culture heros and villains that makes up the common mythology are now in the home and available to everyone. Television is the cement of cohesion in an otherwise diverse and divergent society. The world it presents even encompasses more of the great art and science and philosophy than a whole nation has ever shared before. So what are we to be liberated from?

To answer that question, we have to review some evidence. It bears upon the reversal of the trend toward differentiation of consciousness according to individual and group interest, and the rise of a common environment of stories, ritualistically used, presenting a world according to television.

The World of Television

We have moved away from the historic experience of humankind. Children used to grow up in a home where parents told most of the stories. Today, television tells most of the stories to most of the people most of the time. This electronic pulpit and faithful messenger would be the envy of every Emperor and Pope who ever lived. Children do not have five or six years of relatively protected development within the family and the neighborhood before emerging into the outside culture of school and reading. By the time they can speak, let alone read, they have absorbed hundreds of thousands of stories—programs, news, commercials—produced on the television assembly-line to the specifications of adult tastes and industrial needs. The pervasive mass ritual blurs, when it does not short-circuit, social distinctions rooted in subcultural and class membership, blends community consciousness into its mainstream, and bends that in the direction of its own institutional interests.

How does that work? What is the world according to television like? To discover its main features and functions, we have to look at familiar structures in an unfamiliar light. Rituals rationalize and serve a social order. They make the necessary and inevitable appear natural and right. In conventional entertainment stories, plots perform that rationalizing function. They provide novelty, diversion, and distraction from the constant reiteration of the functions performed by casting, power, and fate. The main points to observe, therefore, are who is who (number and characterization of different social types in the cast); who risks and gets what (power to allocate resources including personal integrity, freedom of action, and safety); and who comes to what end (fate, or outcomes inherent in the structure that relates social types to a calculus of power, risks and relative success or failure).

When observed in that way, as the Annenberg School of Communications has been doing for over 15 years on an annual sample basis, the world of television drama is found to be one in which men outnumber women at least three to one; young people comprise one-third and older people one-fifth of their true proportion of the population, and all other minorities have less than their share of the action but more than their share

of the risks. The lessons learned from that, as we have found by surveying light and heavy viewers in otherwise similar groups, are those that tend to cultivate and confirm rather than challenge or change some of our stereotypic inequities and prejudices.

We have found that the heavier viewers (matched with light viewers by income, education, sex, age, and so on) are less likely to believe that women are as capable as men for responsible positions, more likely to be opposed to open housing, more likely to view older citizens as a vanishing breed, and are generally more likely to respond to our surveys in a way we would call sexist, racist and ageist.

The world according to television also is one in which violence occurs at the rate of 6 acts per hour in prime time and 25 per hour in children's weekend daytime programming.

Violence is essentially a demonstration of power. It shows who can get away with what against whom. Exposure to violence cultivates a sense of relative powers, of one's risks and place in the social hierarchy, and a sense of heightened anxiety and insecurity about a world that is shown to be much meaner and more dangerous than anyone has directly experienced. Insecurity leads to demands for protection, dependence on authority, and acceptance of repression if it comes in the name of security.

For the first time in human history, the resident of the penthouse shares a great deal of the common culture with the inhabitant of the ghetto . . . Television is the cement of cohesion in an otherwise diverse and divergent society.

In the world of television, most people are professionals. Service and blue collar workers who occupy about 60 percent of our population occupy only 10 percent of the television population. The average viewer of prime time television sees a stable cast of about 300 characters a week. Of those, about 44 are engaged in law enforcement and about 21 are criminals. The restoration of law and order is a chief feature of the ritual. And the most general characteristic of heavy viewers compared to similar groups of light viewers is a certain rigidity and resistance to change.

Despite the overwhelming presence of professionals on TV, the process of educating plays a small and ambivalent role. Surveys show that the more children and adolescents watch television, the lower their school and IQ test scores and educational aspirations seem to be.

The Tasks of Liberation

These are a few of the many features and functions of the television mythology that have been studied. But just as important as the individual findings are the results that show television reducing or eliminating differences in people's consciousness of the world around them, and absorbing them into its synthetic and homogenized mainstream. The vast majority of stories that make up the world according to television are made to uniform specifications of institutional service and sales. Relatively rich and attractive though it may be, the world of television acts to screen us from rather than to mediate, the rapidly changing requirements of equity, justice, and survival.

Liberation cannot be accomplished by turning it off. Television is for most people the most attractive thing going any time of the day or night. We live in a world in which the vast majority will not turn it off. If we don't get the message from the tube, we get it through other people.

The strategic conception calls for action on three fronts: as educators, as parents, and as citizens. We can use the skills and insights employed in teaching the humanities and social sciences and apply them to the everyday cultural environment from which all our students learn. Media studies and critical viewing curricula which develop an analytical and critical stance toward mass-produced culture and its television mainstream should be at the center of liberal education.

Teaching students how to be parents in a television culture is also a part of liberation. Participation and discussion rather than proscription or prescription is the best way to put the person, and not the set, in control of the message.

Teaching citizenship in the television age involves the struggle for public access to and real participation in the institutional decision-making process affecting the humanization of our species. This includes a broader resource base enabling the medium to address a greater variety of interests and needs than the middle-majority consumer market. Only then will television be able to create a world of stories fit for all groups in our diverse society.

As teachers, parents, and citizens we can work for a fresh approach to liberal education aimed at liberation from the mass-produced dreams that hurt.

These, at least, are the dreams that heal!

Academic Practices, Freedoms, and the New Technologies

Ithiel de Sola Pool

How do technologies of communication affect academic practices and particularly academic freedom? To answer this question one must both look to the past and speculate about the future.

It is hard to be certain even about what happened in the past. Careers are made debating such questions as the impact that printing had on society 500 years ago. It is harder still to guess what will happen in the future though that is a responsibility which decision makers cannot avoid. Investors, politicians, educational administrators—anyone with responsibility for an institution—must think about the environment in which it will function a decade hence or, in decisions about such matters as tenure or new buildings, even 25 years hence.

As we look backwards, we find much that is similar in what happened in classrooms in the first medieval universities and what happens in classrooms today; or even what happened in the Academy in ancient Athens. But there are differences, as well.

Two major technical innovations changed education during the 1000 years from the time of the first universities to the present. The first was printing. The second was laboratory science. Significant changes in the structure of education followed from each of these.

In the Middle Ages, two things attracted a student to a particular center of learning: the professor at whose knees he would sit; and the presence of specific manuscripts there. Manuscripts of particular works were scarce. Wandering scholars went from place to place in order to read a work where it happened to be located. So the university was a collection of individuals, gathered around particular teachers, learning mostly orally, and often by the study of a manuscript which they parsed together.

Printing changed that pattern. First it led at every distinguished university to a central library in which all the major works of scholarship were located. Second, it made reading assignments possible. No longer did the class sit together around a manuscript, discussing it as they read; the student could be told to go home and read a chapter in a textbook; and, of course, an industry grew up to produce these textbooks.

A third outcome of printing and the production of thousands of books was the democratizing spread of higher education from an activity reaching a fraction of a percent of the population to an experience shared by about half of it.

So printing, which came when universities were about 500 years old, changed higher education greatly, though gradually, over the subsequent 500 years.

The next comparable change, coming in the late 19th and early 20th century was the introduction of laboratory science into higher education. Among the many effects that had, the one particularly worth noting is the introduction of organized group activities into what had been basically a society of individual scholars. Note the growth of multi-authored articles, the hiring of staffs of non-faculty technicians, and the purchase of large shared machines.

So the growth of cooperative multi-person research activities, along with the library and several other centralized facilities needed by a democratic teaching institution, such as, cafeterias, dormitories, and athletic departments have changed institutions of higher education from collections of individual scholars into much more bureaucratic organizations. Fortunately the

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change is far from complete. What makes a college or university different from a consulting firm or an industrial laboratory is that it is still a place where the basic decision as to what a member does is his or her own. There is still what we call academic freedom. The 1000 year old heritage of the university as a guild of autonomous scholars is, gratefully, still with us.

Resisting Bureaucracy

Some years ago, Dwight D. Eisenhower, at his first faculty meeting when he became president of Columbia University, made a warm speech about his plans to do all sorts of good things for the "employees" of Columbia. At the end, I. I. Rabi rose to thank the president and said: "But, Mr. President, there is just one thing; we are not the employees of the University; we are the University."

Despite the fact that we live in a society in which the dominant mode of organization has become the bureaucracy, Rabi was right. In business and in government, the typical organization, as delineated classically by Max Weber, is one in which people are engaged in information activities, just as blue collar employees work eight hours a day in premises away from home with equipment and files they do not own, and are paid a fixed salary for doing so. They do what a superior tells them to do and, similarly, they instruct inferiors.

That is not the way an institution of higher learning functions. Scholars work on their own time, with their own notes, and produce their own writings. Their superiors dare not tell them what to say or do, nor dare they treat their students as employees.

In a bureaucratic society there is a reason to worry about pressures on the university to change in the direction of becoming a more conventional bureaucratic organization. At the extreme, in that respect, are medical schools. Lives are at stake, and besides that, the individual activities of the faculty are swamped by such activities as running a hotel and managing a vast staff of technicians. It is quite natural in a medical school that researchers should have to get permission from a committee before conducting studies that put patients at risk. The institution, not just the scholar, shares liability.

Sometimes, similar structures are extended to the more traditional core of individual scholarship. For example, recently, the Department of Health and Human Services tried to extend such Human Subjects controls to social scientists too, even ones working in a classical liberal arts mode as individual researchers with their notes. Social scientists rose up in arms, and said, as had physicist Rabi, "we are not employees who have to ask permission for what we study." HHS had to back down and exempt most social research as not their business to control.

This digression illustrates how, in a society in which the university remains an exceptional kind of pre-bureaucratic institution, there is pressure to force it into the more normal mode of centralized organization.

Looking Ahead: Autonomy or Centralization

Now let us turn to the future. What will be the impact of the new technologies of communication on the structure of institutions of higher learning? Specifically, will the new developments increase the pressures toward bureaucratization or will they help preserve the autonomy of the scholar? The specific problem on which we may focus is how centralized or decentralized the management of educational technology will be. Will it be done by college-wide audiovisual laboratories and computer centers or will it be a development carried out by individual teachers on their own?

My thesis is an odd one developed more fully in my book *Technologies of Freedom*. The thesis is that the immediate and long run effects go in opposite directions. In the short run, the new technologies of communication do threaten the autonomy of scholars. In the longer run they may foster it.

This can be illustrated with three examples: video teaching, information retrieval, and computer aided instruction.

Teachers have rightly been ambivalent about video courses. There are places where they have great merit. Students in Eskimo villages or in backwoods one-room schools can obtain by TV a

quality of presentation otherwise unavailable to them. Numerous experiments have shown that retention of what has been seen on a television screen is no less than what has been heard from a live lecturer. Yet, excellent as a TV course may be, teachers, under most circumstances, find it to be an artificial, ill-timed intrusion on the pace of the class. There is no way of interrupting for questions. There is no reference to what happened in the class last week or anticipation of what will happen the next week. So even if video education works, it can be an assault on the teacher's autonomy.

There is another problem with television education that is well illustrated by the Open University in Great Britain. A course that is going to be broadcast to thousands of people over BBC has to be right. When individual teachers in ordinary classrooms say something foolish or controversial, that is their academic freedom. Others, including their students or other teachers, may dispute what was said, but it is not a matter of great import. It is rarely important enough to stimulate any kind of bureaucratic interference. But what goes over the air in the name of the Open University is not that sort of individual eccentricity. So every word of every session is made the product of argumentation in a committee.

Yet the result of the committee process is not non-controversial. It may sometimes be vapid because of compromises within the committee. But however carefully phrased, when it comes over the air as the responsible view of the Open University, those who disagree become indignant. Material that would otherwise be an ordinary professor's individual point of view, becomes a matter of institutional policy.

So in an environment in which video is delivered by one of but a few over-the-air broadcasting channels, the short run effect of video teaching is highly bureaucratic. But, that mode of video delivery is changing. Cable systems allow a number of channels of educational video. Still more promising for education is the video cassette recorder which allows the teacher to put a program on at the time that he or she wishes, and to interrupt it for questions or comments.

Still more promising is the random access video disk which allows the student or teacher to cut in at different places in different orders as desired. I have seen an experimental instructional program on videodisk at MIT's Architecture Machine laboratory that deals with repair of an engine. The viewer can stop the presentation at any point and ask for more explanation. The program then branches to a more detailed step-by-step explanation of whatever it was that was not understood. There is also a branch that illustrates mistakes, so the viewer can watch what happens as someone goofs—which adds to levity as well as to understanding.

Scholars work on their own time, with their own notes, and produce their own writings. Their superiors dare not tell them what to say or do, nor dare they treat their students as employees.

When that kind of video equipment becomes standard fare in the classroom, the centralizing bureaucratic character of today's television education will be a thing of the past. The videodisk is no more centralizing than a book.

Some of the same things can be said about information retrieval. Right now, calling data off of data bases is an expensive and cumbersome task. Ordinarily it is done in educational institutions by the professor or graduate student asking a specially trained reference librarian to make the search. The scholar tells the librarian what to look for. The trained librarian, having identified a set of key words that produces a reasonable number of appropriate citations, then asks that they be printed off at the Lockheed or other computer and mailed to the researcher. A few days later, thanks to the United States Postal Service, the output arrives.

There are already expensive ways of doing better than that. One *can* print out the citations on line. One *can* work from one's own terminal on a specialized data base such as DRI for economists or Lexis for lawyers, but very few faculty members currently have either the money or the skills to do so.

The specific problem on which we may focus is how centralized or decentralized the management of educational technology will be.

But what about the future? Some day soon every faculty member will have a microcomputer on his or her desk for word-processing, just as they have a typewriter today. Many will not know how to do sophisticated computer programming, but the retrieval programs will grow simpler and simpler just as the word-processing programs have. "User friendly" is the jargon term the computer people have coined for systems that ordinary people can use.

There are other decentralizing trends in information retrieval. For example, costs of long distance data communication will come down. You have all heard about how our local phone bills are likely to rise. The reason is that technology has shifted the balance between long distance and local costs. With microwave transmission and satellites, the true cost of long distance calls is very little more than that of local ones. Right now, the long distance rates are subsidizing local ones. But that will stop under the divestiture arrangements, so the price of local calls will rise, but the price of long distance calls will fall. That means one need not draw one's data from a local source.

The costs of data communication also are likely to fall. The present phone system was built for voice traffic. Phone people call this "plain old telephone service" or POTS for short. Data can be sent over the voice network but since the system is not optimized for that use, it is not very economical. Data networks, however, are being developed that will make retrieving data from a data base much more economical than now.

So, data base access will become more normal and easier for the user. But the most important change is likely to be in data-base management. The usual procedure now is that a publisher puts together a data base, usually as a byproduct of a reference book in printed form. Then the tapes are shipped to a data base library, the largest of which is Lockheed's. Users access the library in the ways we described above.

The largest cost is the compilation of the data base. That cost will not be much affected by technology. Keypunching from printed copy will, however, largely disappear, since virtually all source material will be in computer readable form to begin with. Nonetheless, data base compilation will remain expensive.

As small computers become widespread, however, it will be less advantageous for publishers to send the tapes that they produce to a data library. Data bases can be stored on their own computers, and the reader can simply dial up that number. There is, therefore, reason to expect development of large numbers of competitive data services, each trying to win customers from all over the world, competing in quality of information and price, and not all storing their data in any one physical library.

What this means to a university is that information sources increasingly will be outside the university itself.

Up to now, libraries have been a main centralizing core of the modern university. They provide free service so they appear on the central budget. The reason they provide free service is not ideological, though such rationalizations have been offered. It certainly is true that free libraries are an excellent redistributive device of which the profession can be proud. But if there were some convenient way to make libraries pay for themselves, that would have long since been done, as most people who are concerned with budgets probably would agree.

The reason it has not been done is the high transaction cost of charging for each use. In the first place, the books have to be bought, and not just the ones that circulate frequently. The most expensive books are likely to be precisely the ones that sit on the shelves unread for years. It would, of course, be possible to charge for checking out books, and indeed lending libraries have existed on that basis. But to do so in a college or university would give incentive to students not to borrow, but to read in the library itself, and thus raise the necessary size and cost of the physical facility.

In computerized information retrieval systems, charging people for what they retrieve is quite easy. Indeed, that is the way that industry operates. With terminals on every desk, users will search out data from wherever it happens to be located. True, they will have to pay, but they will not get any advantage by using a university library as the source, since the library too gets its data from a publisher that has to be paid for usage. It is not like having bought a book as a one-time sunk cost, after which its usage is free.

All this suggests that in the long run there will be a major change in the structure of universities, with the libraries being the principle sufferers. The budget is likely to be restructured to reflect the fact that most information searches cost money, and that most of these searches can just as cheaply, or more so, go directly to the publisher rather than through the library.

There is good reason to worry about who takes responsibility for archival preservation in that situation. Certainly the profit-oriented publishers will not, and if university libraries lose some of their more immediate functions, it is not clear that they will take that responsibility either. But at the same time, the long term effect of electronic information systems is not likely to be centralizing.

Teaching with Computers

Finally, let us speculate about the future of computer aided instruction (CAI). Like television teaching, the first experiments were usually disappointing. The programs were rigid and unresponsive to the variety of problems and questions that students wanted answered. In highly structured subjects such as languages, math, and computer programming, the programs worked well, as measured by performance tests. But even where they worked well, they were expensive when main-frame computers were used. CAI paid for itself in industry where student and teacher time are both paid for, but they were uneconomical in educational institutions where they were simply add-on costs, and any saving in student time cannot be counted.

But that situation is changing rapidly. The pervasive presence of microcomputers, on which there is no billable marginal cost for added use, is one important development. What appears on the screen of those computers today in the form of "Pacman" is interesting and exciting, and such formats, rather than dull and poorly readable question-and-answer texts, suggest that learning can be made exciting. "Logo" does that for a younger population. The ease of course writing and the number of people at home with it will grow as people become used to word processors. Finally, the rapid growth of memory on micros, particularly as hard disk prices fall, means that very extensive branching programs will be possible and teachers will be able to add branches to branches as problems arise.

Given the present rate of growth of computers in the classroom and in students' residences, some time in the next decade there should be a major take-off in the use of CAI. I am definitely not suggesting that it will displace the teacher any more than the book did. And I am not suggesting that it will displace the book either. But we know from many tests that under appropriate circumstances CAI works. The problems are institutional and economic and can be overcome.

Much computer aided instruction will be in the classroom, and should be, so that the teacher can be there. My son teaches a course in political science research methods at the University of Washington. He has just finished teaching it for the first time entirely by CAI. I asked him how the students liked it; he said they like it, though they also claimed they had never worked so hard. I asked him what *he* had learned from it. He said his main conclusion was that it greatly increased the time spent in student-teacher interaction. Every day he found in his computer mailbox far more questions from the students than he ever had in a class, and these he had to answer individually. Also, as in a science laboratory, much of the teaching he did was one-on-one in the computer lab.

Much of the student work was also at odd hours when he was not around, and so the students then sent queries. None of these students were working from their rooms, for that facility is not yet available to them, but soon it will be. So, while much of the future use of CAI will be in the classroom, much will undoubtedly also be homework.

How will institutions of higher education change when the changes described occur? How will they change when a substantial part of the teaching is computer aided, using microcomputers in both the classroom and at home, when information retrieval is done on the same computer equipment via direct query to the publisher, and when video teaching is done off computer controlled disks that are linked to the computer teaching programs? What all this suggests is that the

opportunities for individualized instruction and for autonomy of both teacher and student will be enhanced, not diminished.

But that is a statement about the long run. Such consequences depend not only on the existence in the laboratory of devices like interactive videodisks and large memory microcomputers, but also on their pervasive diffusion, and that in turn depends on falling costs.

As Keynes said, "In the long run we are all dead." The death to be feared in this instance is precedents that may be adopted in the short run if we mistakenly respond to immature forms of the new technologies. To take advantage of the new technologies of communication in the mature forms that will exist in the future, academic institutions must hold firmly to their 1000 year old tradition of the autonomy of their members. They must fight off the pressures toward bureaucratization of their structure. Despite the fact that with videoteaching and computer activity in its early forms more and more of the university seems to be involved in interdependent activities involving expensive central facilities, the trend in the end will be in the opposite direction.

The Library: Center of the Restructured University

Patricia Battin

As Franklin Wallin, the president of Earlham College, observed in a recent article in *CHANGE*, "Universities have not moved much beyond amazement at the cost and power of the technological engines that drive this shift [from an industrial society to an information-based society], the computers and telecommunications that can come up with answers in nanoseconds and transmit them to everyone around the world in minutes. We struggle merely to keep up with this technology in our universities. We have scarcely taken time to understand the educational implications of the change or conceive what a university might be like in the context of an information age."

For at least a decade, librarians have been very much aware of the revolutionary impact of developments in information technology. But the expansion of computer capabilities occurred at a time when research libraries were experiencing, for unrelated reasons, serious obstacles in serving scholarly needs. The traditional bonds between scholars and librarians have been substantially eroded, and librarians' efforts to reinvent the library in the electronic environment have often been actively opposed, widely misunderstood, or more generally, completely ignored by scholars and administrators. In addition, there appears to be widespread misunderstanding of the function of the research library in the process of scholarly communication and a pervasive misperception of the "library" as no more than a storehouse for books. As often happens in academic institutions, symbols become enshrined in mythology and mortgaged to territorial jurisdictions, with the consequence that the basic function is obscured and overlooked.

Traditionally we have defined the library as a storehouse where librarians "mark and park," rather than as a place which has a scholarly information function within the university. The introduction of computer and communications technologies into the society were initially viewed as separate and distinct activities unrelated to the historic functions of the library. The traditional organization of the university into largely autonomous units further inhibited the recognition of the essential relationship between the new technologies and the information function of the library. In keeping with conventional organizational structures, university administrators departmentalized the function, establishing an organizational barrier between libraries and computer centers. For almost a decade, there was little recognition that advances in communication technologies were radically affecting the ways in which scholars communicate.

One of the most powerful deterrents to change in conservative institutions—and I think the educational institution is one of our society's most conservative institutions—is the existence of strong autonomous vested interests and the fear of losing one's empire. Universities are notoriously allergic to systematic, long-range planning efforts and have thrived for centuries on academic star-driven hiring practices and program development. Consequently, the capacity for the kind of substantial, integrated, long-range institutional planning required by the revolution in information and communications technologies is lacking in most institutions of higher education.

The weight of our historic traditions is such that we tend to find it very difficult to look at the future in terms of a vastly changed organizational

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structure. By asserting the need for continuation of historic entities, like the Library or the Computer Center or the Office of the Provost, the necessary creative vision is stultified. The challenge for us all is to look at the realities of the present and the forecast for the future from the perspective of disinterested, objective university officers and then to re-invent the university in the electronic environment.

I would like to analyze briefly the function of the library as we have known it historically, summarize some of the current activities in the library profession, and suggest the new capacities required by the modern university to continue to provide the essential level of scholarly information support. Such an analysis should provide an understanding of how best to organize the existing talents and strengths within the university to meet the new challenges.

The word "information" is a troublesome one. Academic librarians have always distinguished between "information" and "knowledge," and our basic philosophies and objectives have arisen from a commitment to the organization of knowledge and the support of continuing scholarship. Contemporary information managers and computer specialists tend to treat all information as data and are concerned more with the technical aspects of hardware and systems than with the substantive content of data and its influence on systems of organization, storage, access, and retrieval. I use the term "scholarly information" to define that subset of the information society which is vital to the university a..d to librarians as professionals historically concerned with providing scholarly support services.

Traditional Roles and Services

Bill Ward, president of the American Council of Learned Societies, recently defined the ideal in library service from the scholarly perspective: "Scholars want what they want when they want it whether or not they know what it is they want." In the past, the university has sought to serve this fundamental need by maintaining bibliographically controlled archival collections of the printed record.

The traditional role of the librarian in the age of printed formats—books, journals, and microforms—has been essentially archival. The mission of the research librarian became the acquisition, recording, storage, and preservation of the intellectual record in printed form.

For over five centuries, the book has served as the uniquely useful method of storing and transporting text and images assembled by the mind of an author. For more than a hundred years in the United States, librarians and scholars settled into a comfortable framework of scholarly communication in which the library represented the essential link in the chain by mailing books available to scholars. The publication explosion, the rapid and inexorable expansion of knowledge and interdisciplinary research, the pressures of the "publish or perish" syndrome on the scholarly process, the demand for speed in information retrieval, and the radical changes in the financing of higher education, all combined two decades ago to begin to reduce the effectiveness of the traditional library in the scholarly process.

Traditional bibliographic services reflect the limitations of scholarly communication through easily described and identifiable physical objects residing in reasonably stationary collections. The card or book catalog, a physical representation with its own set of constraints, set the pattern and the standards for a scholarly methodology of access to knowledge. In this era, the catalog served largely as the inventory of a specific collection of materials, and its records were linked to a specific location. Its usefulness as a scholarly tool depended upon the scope, size, and comprehensiveness of the collection it described.

The revolution in information technology has created, quite apart from difficulties caused by financial stringencies and publication explosions, totally new capacities for generating, storing, and providing access to scholarly information—capacities which no longer represent or require links to physical objects in stationary collections. Communication among scholars has been liberated from the limitations of the printed page, and that liberation has brought with it the corollary demand for a new set of lifelines.

Universities are now faced with a dual challenge: we must provide new structures of access to knowledge in an increasing variety of formats and, at the same time, continue to preserve, man-

age, and make available scholarly information in the traditional printed formats with appropriate links between all formats.

It is essential to emphasize that the whole structure of our research activity in the United States, as we know it, is based upon the knowledge access structures conceived and built over the years by the library profession. Now it is quite possible that many of these activities are costly, outmoded, and do not deserve to survive the transition to the electronic age, but I think we must understand the actual function of libraries in the process of scholarly communication in order to insure a continuation of essential functions in the new environment.

As often happens in academic institutions, symbols become enshrined in mythology and mortgaged to territorial jurisdictions, with the consequence that the basic function is obscured and overlooked.

The most striking feature of traditional academic organizations, and the one I believe is most misunderstood and ignored by our academic colleagues, is the virtual isolation of the library in the organization. Despite the rhetoric about it being "the heart of the university," the library and librarians have been for years isolated from the policy councils of most institutions. This isolation was possible because our present system of research support evolved from a tradition of autonomy, symbolized by the autonomy of the printed word. Public policies governing access to information and institutional structures implementing those policies reflect that autonomy. There is a kind of double-speak in this respect. The Library has been organizationally treated as an isolated, autonomous component of the institution. Yet, increasingly, its function is to provide integrated services on the local, regional, and national levels. The resulting tension between the functional expectations and the organizational realities have contributed to the current perceptions of ineffectiveness and impotence.

The new communications technologies require new collective approaches which in turn demand radically different organizational structures to create and support such enterprises. The extreme frustration of the library profession is matched only, I believe, by the frustration and undeserved disdain of administrators and scholars for the library profession's perceived inability to cope with the new demands.

In summary, we have built during the past five centuries a remarkable and successful educational and research establishment centered around the book as the primary medium of scholarly exchange. But, despite the age of our system, we really know very little about how this process actually works or what we need to assist us in the task of re-invention.

New Communication Links

The needs of scholars always have transcended local barriers, and, for the past decade, the library profession has been engaged in developing new communications links between the disparate components of our decentralized "national library." Although the Library of Congress often acts unofficially as a national library, it is precisely what its name implies—the Library of Congress—and all efforts to establish it as a truly effective national library, responsive to the needs of the national scholarly community, have failed.

The American "national library" is a decentralized system composed of the Library of Congress, the National Library of Medicine, the National Library of Agriculture, and approximately one hundred private and public research libraries located across the nation. In the new environment in which the bibliographic machinery no longer represents a mirror of a physical collection, librarians' efforts have been concentrated on ways 1) to provide new structures of access to new formats of knowledge no longer bound by physical and geographic constraints, and 2) to link the multiplicity of scholarly resources, both print and non-print, into an easily accessible system which will eliminate costly duplication and the unacceptable isolation of individual scholars.

The complexity of a decentralized private and public research library system in the United States is further compounded by the emergence of powerful corporations in the for-profit sector which are seeking control of the "knowledge industry" and introducing the concept of fee-per-use of information. The fact that our copyright laws do not adequately address the issues of copyright protection and the ownership of information in the electronic environment creates additional difficulties. Within this context, there are several major efforts now in progress to provide rational, affordable, computerized information services for scholars.

The Library of Congress provides, via its MARC tape service, the records of its cataloging in machine readable form. The LC Name Authority File also is available on line as are the bibliographic records from the Government Printing Office and the National Library of Medicine. There are three bibliographic utilities which distribute these machine-readable records to libraries across the country. In turn, the participating libraries, using varying standards, contribute bibliographic records with location symbols prepared for materials not yet recorded in the data base. The phenomenal growth of these data bases has resulted in a vastly increased capacity to share cataloging responsibilities and thus reduce local institutional expenses. The existence of these large data resources has revolutionized interlibrary loan capacities and made possible the potential for developing a coordinated national collection through new means of access to decentralized collections.

The two major bibliographic networks—OCLC and RLIN—provide information on a combined total of 18 million unique records for books, maps, manuscripts, periodicals, audiovisual materials, sound recordings, and music scores. OCLC maintains a large research and development capacity for the exploration of new technologies, primarily involving interaction between information seekers and computers (commonly referred to as "user-friendly" interfaces), electronic document delivery, microcomputer applications in libraries, and on-line catalog requirements. The corporation recently has announced its intent to commit a substantial portion of its research efforts to the development of a national communications service, including electronic mail and facsimile transmission capacities.

The Research Libraries Group (RLG) represents a focused effort by a number of research universities and their libraries to reshape information services for scholars. In contrast to OCLC, which is a mass-market driven enterprise, RLG derives its direction from the program needs of its owner-member research institutions. Perhaps its most dramatic achievement to date is the development of a computerized capacity to achieve bibliographic control of East Asian vernacular material. The development effort will permit computer supported creation, copy, amendment, search, display, and output of bibliographic records composed of East Asian characters. In addition to standard bibliographic services, RLG also maintains on RLIN several special data bases, including the Avery Architecture Index, SCIPIO (an index of art sales catalogs) and the Eighteenth Century Short Title Catalog. Plans are underway to create a special data base of bibliographic records for machine readable data files in the humanities and social sciences.

For more than a hundred years in the United States, librarians and scholars settled into a comfortable framework of scholarly communication in which the library represented the essential link in the chain by making books available to scholars.

At the present time, the utilities are not linked, thus creating serious access problems for scholars since institutional participation is usually limited to one utility. The Council on Library Resources, a privately funded foundation, launched some years ago a Bibliographic Services Development Program to help bring into existence a comprehensive logically consistent, non-redundant data base of bibliographic records. To insure comprehensiveness, the data base must be built by a set of cooperating, contributing institutions adhering to a common set of standards. The element of

non-redundancy requires the use of an authority file to record the entities that have been created according to the set of accepted rules. The objective of this program is to create a widely available, cost-effective bibliographic record service that will incorporate the resources of the major shared cataloging services and provide access to a variety of bibliographic data bases in a manner transparent to library users.

For the past three years, the Library of Congress, the Washington Library Network, and the RLG have worked on a cooperative project funded by the Council on Library Resources to develop a standard network inter-connection which consists of a seven-layer communications protocol which will permit computer-to-computer communication. This project will be completed by the end of 1983 and represents an extraordinary example of library leadership in the application of communications technology for academic purposes. Plans are underway to develop the capacity to conduct bibliographic searches through the links with the ultimate objective of full-text transmission.

The relatively sudden availability of affordable personal computers promises another major revolution in research information services within the next five years. The new powerful microcomputers will have storage and retrieval capacities equal to the large mainframes of the past decade. Many American universities are planning the "wiring" of their campuses to support the demand by students and faculty for computerized information services. Both RLG and OCLC are planning technical architectures which will permit the orderly and effective decentralization of many currently centralized information services, and we are beginning to see the first efforts of the for-profit sector to market bibliographic information directly to the end-user, a phenomenon which transfers costs normally borne by the institution to the individual scholar on a per use cost basis.

But the technical systems represent only a capacity to communicate. The effectiveness of new systems of access to scholarly resources will depend upon the cooperative efforts of the university community to identify and develop the substance of new structures of access to knowledge, a process which will demand new organizational capacities in the university.

Policy Implications

There are six major policy areas which will demand specialized and unprecedented attention from university officers during the next five years. In each of these areas, an organizational mechanism to draw together currently disparate components of the university is required for effective action.

1. Centralized financial and technological planning. The successful and cost-effective integration of the various information support services will require a centralized long-range planning capacity and a re-cast budgeting process to accommodate the following characteristics of the new services:

a. the archival obligations of scholarly information support services, regardless of format;
b. the introduction of high technology with its corollary built-in obsolescence;
c. the magnitude of the capital costs required;
d. the integration of services offered through book and journal collections, mainframes, microcomputers, and local area networks;
e. the provision of access for local scholars to external knowledge data bases, networks, etc.

2. Integration of information services with academic programs and priorities. In contrast to other "information professionals," academic librarians have traditionally made substantial contributions to the organization of knowledge within the old structure of printed formats. The new formats will require similar efforts to build new access structures to knowledge and to work with scholars in identifying and defining the basic access structures in each discipline which must be mastered to enable informed judgments. More so than ever before, a university or college degree should certify a certain level of bibliographic literacy and competency in information sources in a particular discipline. There should be within the university a central capacity to assist the departments of instruction and research in the development of these skills.

If the scholarly community is to be effective in this unprecedented struggle for control over its life-blood, it must transcend its cherished autonomy and create organizational mechanisms which will support effective cooperative activities in its own best interests.

3. Access to scholarly resources. As mentioned earlier, one of the major contributions of the library profession to scholarship is bibliographic control over the printed record. A problem for computer data archivists today is the lack of attention paid to these issues during the early days of data collection by computer specialists and scholars.

The Roper Center estimates a five to ten year effort will be necessary to achieve the cataloging necessary to enable effective retrieval below a very broad descriptor level. We need to know a lot more than we do about the specific ways in which scholars will use on-line information sources, but we do know it will be essential to provide orderly and standardized retrieval mechanisms in considerable depth for archival collections in all formats. National agreement within the scholarly community on a variety of standards affecting cataloging activities, communications networks, and hardware capabilities will be essential to prevent both the unacceptable isolation of individual scholars and a generalized Tower of Babel.

4. Electronic publishing. The advent of electronic capabilities provides the university with the potential for becoming the primary publisher in the scholarly communication process. At the present time, we are in the untenable position of generating knowledge, giving it away to the commercial publisher, and then buying it back for our scholars at increasingly prohibitive prices. Universities have long served as publishers' distributors and warehousers and have served that role because of the perceived advantages in having a form of ownership control over purchased information.

The electronic revolution provides the potential for developing university controlled publishing enterprises through scholarly networks supported either by individual institutions or consortia. Increasingly, scholars are producing their work in machine readable form. The lacking ingredient is the organizational capacity for on-line refereeing, editing, and distribution, as well as the necessary modifications in the process of assessing publications for promotion and tenure.

5. Copyright and ownership. Our present copyright laws essentially address the issues surrounding the ownership of printed formats. There will be substantial revisions during the next decade, with significant implications for educational institutions. Commercial publishers have been moving steadily during the past ten years to substitute a fee-for-use principle for our historic tradition of multiple uses of documents after their initial purchase. Computerized indexes and abstracts are now available both on a fee-for-use basis and in hard copy. When the publisher decides to discontinue the hard copy, the only access will be through the computerized service with monopolistic control over the fee structure held by the publishers.

The implications of information ownership issues arising from the basic conflict of information as a commodity and information as a public good are serious. It will be essential for the university community to develop a capacity for thoughtful, critical analysis of the issues accompanied by significant influence on public policy.

6. Research and development in information technology. Universities are faced with the unprecedented requirement of basic research in the very substance of their existence—information technology. In the past, the existence or absence of the capacity for cutting-edge research in a particular field threatened only the survival of a particular department or discipline in the institution, rather than the institution itself. Now that information is valued as a commodity in the society, competition with the private sector is unquestionably beyond the financial capacity of individual institutions of higher education. To maintain control over their own scholarship and to avoid becoming a hostage to the for-profit sector, universities must find a way to create and support the capacity for continuing research and development in the application of information technologies. Otherwise, the university will continue to lag behind the for-profit sector in the very area of its *raison d'etre* and be forced to adapt its research and instructional needs to the marketplace rather than control the application of appropriate technologies to support scholarship.

The Institute for Scientific Information is marketing a software package to provide individual searching of a wide range of bibliographic data bases. The software and companion data base management package costs approximately $1000

per individual scholar and represents one such need. A university supported capacity to develop and maintain a variety of software tools for its students and scholars would be both cost-effective and enable the scholarly community to retain control over its information costs. In some ways, such a capacity is different only in kind from the long-standing traditional university production of textbooks and the card catalog; both are software aids for communicating and retrieving information. There are similar examples in the hardware field, where mass market appeal will drive the affordable availability of new technology.

The most important issue, to my mind, is the need for a cooperative, unified voice for scholarship—not just for science or humanities, or a voice for biomedical pursuits—but all scholarly endeavors. The new communications technologies will acquire an extraordinary and unprecedented cooperative effort to insure compatible, affordable, widely available access structures to knowledge, transparent to the users. The financial pressures on the higher education community will be intense as the for-profit sector seeks to gain control over ownership and dissemination of information as a commodity. If the scholarly community is to be effective in this unprecedented struggle for control over its life-blood, it must transcend its cherished autonomy and create organizational mechanisms which will support effective cooperative activities in its own best interests.

Another Perspective

It may be useful now to review this analysis from a less objective perspective.

It seems that modern information and communications technology have destroyed the viability of the traditional organizational structure of the university as a collection of largely autonomous units based on historic disciplinary definitions. Although it is true that the library has not been central to the academic institution in organizational terms, its function has always been central to research and instructional activities. The definition of the library and librarian may be obsolete, but the function is critical to the survival of the university.

The library is the organizational unit within the institution which contains the nucleus of talent, expertise, and conceptual understanding of the process of scholarly communication. The profession of librarianship, which must expand to encompass its new responsibilities, is the obvious choice for leadership. Substantial elements of the new capacities needed by the modern university exist within the traditional library organization. They need to be strengthened, expanded, and enriched by bringing together under a principal university officer for scholarly information the various talents and functions scattered throughout the institution.

I am not defending a vested interest; rather, I am seeking to vest a new interest. It is unfortunately true that the library profession has not reformed itself rapidly enough to meet the new challenges—but neither have the scholarly disciplines. Because the profession is viewed as one of low prestige and lower salaries, we have failed to attract the necessary talent in sufficient numbers. We must not become unduly dazzled by the wonders of hardware, software, and the wizards of high technology to the extent that we jettison a rich and productive tradition of scholarly support because that particular profession does not, at this point in time, command the necessary depth and breadth of talent and respect.

The new organizational structure would mean that we can draw into an existing strength the talents and expertise of individuals newly committed to the management and provision of scholarly information services and create an institutional capacity to re-invent the university in the electronic age.

The Post-Gutenberg University

Steven Muller

"The Post-Gutenberg University" as a title is rather interesting because it raises the question of the extent to which the present university could be fairly characterized as the Gutenberg University. In view of the fact that the lecturing technique has successfully endured four centuries of writing, it might be that we will move directly from the pre-Gutenberg to the post-Gutenberg era.

What I would like to suggest is that we are, whether fully conscious of it or not, already in an environment for higher education that represents the most drastic change since the founding of the University of Paris and Bologna and the other great universities some eight or nine centuries ago. Our problems are, therefore, fundamental and radical.

There are four major areas in which the colleges and universities of the very near future are going to be radically different from where we still are and where we have been in the last 20 or 25 years: we are going to serve a substantially altered clientele; we are going to deliver our services in new ways; the content of our service is going to be different; and the style in which we operate is going to change.

The one given is, of course, that we are all short of money now and no matter how well we do in the future, we will always be short of money. That is the only constant on which we should count.

Even though the clientele will change, the audience for higher education in American society in the years ahead will continue to some extent to consist of people who have emerged from school and have not yet entered careers. This may be only because we really have to continue serving one of our primary social roles which is to provide a place where that generation can aggregate in a peer group context for two primary reasons: on the one hand, it is intolerable for them to continue to live at home, intolerable both for them and for their parents; and, on the other hand, it is intolerable for the economy to absorb them into the labor force. In some sense, we render a social service by keeping them out of the labor market and away from their families. And since there is no evident replacement for that, we will continue to serve them. They will, however, for a variety of reasons, constitute a significantly lesser fraction of our clientele, and over the longer run, it may be that our service to them will be less than half of what we do at the collegiate and university level.

The New Clientele

An increasingly greater fraction of our clientele will be older people, many of whom will have gone through at least a collegiate state of higher education earlier, many of whom will also have gone through advanced professional or graduate education, but who will be looking to institutions of higher education for retraining in their own field. That is going to be mandatory because the state of knowledge now dates itself so rapidly that it is inconceivable that someone who emerges with the latest learning in any field is going to stay in command of that latest learning for more than a decade. And if that person is going to be engaged professionally for longer than ten years, that person is going to seek relearning. At least a part-time exposure to reacquaintance with one's own discipline is going to be a given in all careers. It is beginning to be that way now and that growing audi-

Steven Muller

ence, therefore, will look more and more to us to deliver these services in the future.

Along with the demand for up-to-date knowledge comes the fact that Americans are living longer. It is likely that life expectancy will increase even more. We will have a large part of our population quite vigorously active through the ages of 70 to 80. This population of people may or may not be actively engaged professionally but will have active minds and will presumably want to occupy part of their time with educational activities, but not necessarily for professional or credentialing purposes.

Underlying that is a more important phenomenon which is that we are living now and will live in the future, to a greater degree, in a society where leisure is a part of virtually everyone's life. This is not to suggest that present levels of unemployment will remain indefinitely as high as they are and that it will be the leisure of the unemployed. Rather, if we examine the way we live today, the least noticed aspect of our American civilization which we share with the most highly developed countries of the world, is the degree to which leisure, which as little as a century ago was the privilege of a small aristocracy, has been democratized.

It is not really possible any longer for people to spend much of their lives effectively in what used to be called toil. Farming, for example, is still an occupation that takes a lot of time but it is not as physically exhausting anymore because most of the physical labor now is done by machinery. Production has become and will continue to be an automated process, and it is predictable that the robotics which we already are witnessing will increasingly take over the manufacturing and production process. If we look at the American home, it is difficult to conceive of a homemaker, male or female, really slaving in a kitchen because one does not slave over a microwave oven. We are not far, presumably, from the home computer where you put your order into the market and the meat carved by computer or robot arrives at your door. Presumbly it will still be delivered by hand.

Almost every adult now has time on his or her hands which can be considered prime time because it is not the few minues at the end of 12 or 14 hours of exhausting labor. It is time after labor which has not been exhausting. It is time during which one has the energy to be alert. It is also potentially dangerous time because, for many people, leisure spells boredom and their problem is how to occupy that time. But that leisure is present.

It is interesting to note that just in the last two decades in this society and in other societies like ours, a whole new industry has been formed which is designed to produce something jobs no longer produce: namely, sweat and exercise. It is inconceivable that nineteenth century Welsh miners would spend their free time jogging. They presumably did not need to worry about keeping physically fit. But the fact that we have everything from European health spas to enterprises that are springing up everywhere which are designed to tune you physically means that we no longer get that from the working day.

Think not about the money to be made in that industry or whether you should join in this happy group of exercisers, but think about what it means in terms of the existence of leisure in our society. The fundamental character of human beings is not going to change all that much, nor will everyone who has leisure have an appetite for education. But out of sheer boredom alone, some people are going to look at education as a potential means of entertainment, and they are going to look to us to provide that. What that means, basically, is that we are going to serve a clientele which is adult, which wants to participate in education for a variety of reasons such as professional—either retooling in their field or learning a new field—or personal—for entertainment or cultural value or learning for learning's sake. This new clientele will probably be on a part-time basis, rather than necessarily wanting to be in residence on our campuses.

New Services

The character of our clientele is linked to my second point: the way in which we deliver our services is already undergoing rapid change and will be radically altered within the next two decades. The combination of television, microwave transmission, satellites, cable, fiber optics, and computers means that we are already capable of delivering educational services to people where they work and live by the use of electronic communications. The biggest curse of that technology to date,

namely, the fact that it is difficult or expensive to make it interactive, is about to disappear. It is now absolutely necessary to be aware that probably before the end of the 1980s, or certainly by the 1990s, it will be perfectly feasible and economical (if you can charge a fee) to have a communications link between a teaching agency and a client location which is wholly interactive in terms of sight and sound and which can be individualized according to the needs of the client. It will be possible, for example, at any hour of the day, through microwave, cable, satellite, telephone wire, or whatever, to have a video and audio link so that there can be discussion with an instructor in one place, and the audience someplace else.

We will be able to reach people in their homes and all they need for reception will be a cathode ray tube. They already have those, and they probably will have more of them or a more sophisticated form on which all of these things take place. Our institutions of higher education will also have them. Because that technology exists, its use will be demanded of us, and we will use it. The only question that remains is how some of us will adapt to those uses.

How are we going to carve up that new audience and where are we going to deliver these services? Are those of us in metropolitan areas going to serve primarily clients in our own metropolitan area? Will major universities with large and scattered alumni bodies serve their alumni as a primary audience being indifferent if they are located in the Northeast and their alumni are in the Southwest or Far West? It probably does not make any difference because these media of communication are distance- and space-independent.

To what extent will this be internationalized? To the extent that English is the telecommunications *lingua franca* of today, will transmission in English be satisfactory to reach audiences at least in English-speaking countries? How far are we from getting past about the only other major global obstacle we have left, which is computerized instantaneous translation of language? Probably not very far.

It is highly likely that, before the end of the century, it will be possible to make input into these electronic media in English, and by computerized translation have an audio output at the other end

In serving a different audience, our delivery systems are going to change, because it is inconvenient, expensive, and unnecessary for people to come to campuses when they can be far more effectively served where they live or work.

in Russian or Chinese or Japanese or German or Italian, and vice versa. This means that in serving a different audience, our delivery systems are going to change, because it is inconvenient, expensive, and unnecessary for people to come to campuses when they can be far more effectively served where they live or work. In many cases, one has to ask oneself what the campus offers that is indispensable.

We need to examine to what degree audio/video contact is *manqué* in terms of human communication. Is it better if, at the beginning and at the end, one actually can feel the person? How necessary are the feelies and smellies, if you can see and hear? If it turns out that, to a large extent, this technique works as a substitute for being in the same room within smell and touch of each other, then what about the fact that you need laboratories to teach science?

If you are reaching people where they work, and if there are laboratory facilities where they work, it may be cheaper for the company interested in continuing instruction for its employees to let them use corporate labs (if the facilities are roughly the same) which are tied into university labs with audio/video equipment. Then, the employee can see a university laboratory with a professor doing something and replicate that process in their own laboratory. What, if any, difference is there going to be between working side by side at exactly the same installation and working side by side at different installations but linked by video and audio? If there is no need to bring students into laboratories, then why is there any need to bring them to campuses at all? Examinations? Well, multiple choice, of course, can be done anywhere, but even oral examinations could presumably be conducted this way and probably will be.

New Content

The third point is that the content of what we do is going to change. We are all going to have to jolt ourselves out of our habits of perception and rethink, individually and collectively, what we believe learning is. To a very large extent, we have all become habituated to equating learning with at least two things: memorization and reading. Both are undoubtedly part of learning, but they may have to be rethought in terms of their actual role in the learning process because of the new technology that is now available.

Everyone knows about computers. Computers, among other things, are extraordinary tools for enhancing memory. Properly programmed, a computer can produce with accuracy and great speed an enormous amount of data. If you want to know, for example, all the kings of Britain from Alfred the Great or Norman the Conqueror onward, you can laboriously memorize them and their dates, or you can punch them in the computer and there the screen is, full of them. And every name presumably will be spelled right and every date will be correct. The interesting question is why, in heaven's name, would you want that information? Even more interesting, though, is the question that if it is already true that the new technology provides memory enhancement—a quantum leap in terms of what human beings have been able to dispose of before—then what is the point of putting such a stress on memorization?

Shouldn't we really be educating people to the point where they know what kind of data they want to use and why they want that data, and then have the mental capacity to deal with that data to address a problem when they have it? We have said that we teach people to think. To some degree we do that, because some of the things that we ask students to read presumably prompt them to think. Most of our examinations, however, really ask for what they can recall.

It is interesting that there are arguments in faculties with which I am acquainted about the degree to which you allow the students to bring some of these memory enhancers into the classroom when they take examinations. Are we going to insist that students recall data in their own minds when in real life later they are going to use the computer for that data? We may have to rethink what an examination is, which leads one to rethink what we really are asking people to do. What are we trying to educate them to do? If we are serious about educating people to solve problems, is there anything left that enables people to integrate what they know, because we have compartmentalized knowledge so much? Are we in danger of having people who can manipulate data and hide it in compartmentalized ways? Should we teach them how to integrate what they know into some meaningful framework? That has not been accented in our educational processes lately.

We are all going to have to jolt ourselves out of our habits of perception and rethink, individually and collectively, what we believe learning is.

We are going to have to teach people how to screen out data. It used to be that the mind could not remember enough. Now the mind is going to have enough data at its disposal to drown any sane person. We are either going to have to teach people how to live insanely—we are doing a good job of that so far—or we are going to have to simplify the data for them, which means an educational process that tells you: This is what you need to look for and other stuff is not relevant.

We are also going to have to re-examine the role of the word—the spoken and printed word—as the primary vehicle of communication. One may immediately assume that numbers are relevant here, and that it is legitimate to communicate in numbers. But it has not been legitimate in Western civilization for several centuries to give serious weight to communication and learning by images. Yet, of course, it is true, if we go back to what little we know of the origins of our society, that images have always played a powerful role in the transmission of culture and in the transmission of concepts. We are living now with a technology that enables us, whether we want to or not, to be exposed to the most powerful imagery that humankind has been exposed to, that is, living color and sound on a giant scale.

As long ago as the early 1960s, I had an experience teaching comparative government at Cornell University where students did not respond particularly well to reading what was then considered contemporary European political science or history. But when they were given the opportunity to see old newsreels, they packed the hall, and all of a sudden the whole thing took on new meaning. In those days we were trying to remind them of people like Hitler and Mussolini, who were not yet history in the textbooks. But they had existed before the living memory of those students. Those personalities as living presences on the screen became powerful. We are going to be able to recreate everything to a large extent. The commercial industry has already done that: we have seen Charlton Heston as God and Moses and Ronald Reagan as President of the United States!

We are also going to have to teach people by the use of images, and we are going to have to legitimize that process. And that again raises questions about the learning process, the teaching process, and the examination process. In addition, it means that the content of what we do is going to have to change, and in doing so, it will solve some awful problems.

As a result of the society we live in, our attention span has shrunk. The ability of the average person to absorb anything for any length of time has been truncated a great deal. There is solid evidence for that: speeches are shorter, jokes are one-liners. We know the attention span is shorter and also know that much of what we have done traditionally in teaching is boring, particularly in comparison to the entertainment media. It is probably heresy for the president of a traditional university to suggest that we should compete with the media and be entertaining, but if we do not compete we will go down the tubes and our campuses are going to be roughly like the old nunneries that have been abandoned by the order. The technology is there, and it is made to be used. In fact, it may be necessary to achieve integration by the use of images. The marriage of the picture to the word is not unrespectable; it is traditional.

In computer imaging, we can design our own images as we go along. We are going to have to teach that way if we want to teach at all. And our teaching will have to be more effective than it is now. It is not a question of whether you like it or whether you find it startling. Either you will be doing it, or you will be a client—as an unemployed person—and somebody else will be doing it.

Furthermore, our old ambition to turn out a finished product is nonsense. The fact is that the best service we can now render, especially for those young people who are aggregated for social reasons on our campuses, is to give them a good fundamental education. To train them in the state-of-the-art is terrific, except that the state-of-the-art is gone three to five years later, and they will have to catch up with it again. More importantly, we ought to be training them to be lifelong learners, not as a hobby, or simply to escape boredom, but because they will need it professionally. That means we have to rethink our content in those terms, too. We need to rediscover what the fundamentals really are and to give our students some context into which they will orient their learning process for the rest of their lives.

New Ways of Operating

The fourth point is that the style in which we do business is going to change. A great many people are now worrying about how to support full-time students for the indefinite future, when they really ought to be worrying about where to solicit the part-time clientele that they are going to be serving, how to serve them best, and how to pay for that service.

At a place such as the university in which I now serve, it is becoming almost a matter of indifference what we pay people in the sciences, because the payroll is only a small part of the cost. To hire a full professor of chemistry or microbiology, we need to be prepared to spend between two and four million dollars in laboratory equipment. For example, if we have a great graduate program in medicine, we may need to have two or three nuclear magnetic resonance spectrometers. But is a Hollins or a Haverford going to have that? What is going to happen just to the teaching of science?

There may be an answer to that, and that is that 3,000 disparate institutions in the United States, each of which is marked by an unquenchable desire to survive and a parochialism to match, may actually have to become serious about sharing. Sharing may just be one of the ways in

which we apply the new technology, by reaching out to students where they live and work, and by offering certain kinds of science instruction that can only be given by institutions which have sophisticated resources for that purpose, and which need to be shared with institutions that, either because they are different or because they have concentrated on something else, simply do not have these resources.

We may also find that we are sharing globally. I have talked on my own campus about the emergence of world class universities which are in touch with each other because they have more in common with each other across national frontiers, oceans, and so on, than they do with colleagues who are working at different levels in domestic institutions only 20 miles away.

Sharing may just be one of the ways in which we apply the new technology, by reaching out to students where they live and work, and by offering certain kinds of science instruction that can only be given by institutions which have sophisticated resources for that purpose, and which need to be shared with institutions that . . . do not have these resources.

An obstacle to international cooperation has been travel; the new communications may make that travel less relevant, less necessary. Instead, we will have interconnections, networking, and sharing. For example, we may save on library resources because we will no longer maintain all those books which are chemically decaying anyway. The publishing industry is going to have to face the fact that if we can transmit text electronically, we can also print it out on a printer. The question is, who do we pay to have that done? It is technologically possible and it may be cheaper than buying a book. And the paper may become biodegradable, so that after reading it, you can eat it, or it will self-destruct!

The potential hazards of a post-Gutenberg university can be frightening. At worst, it could be that we are talking about a post-Gutenberg university which will become mechanistic, impersonal, alienated, and superficial and whose dealings with its students or clients will be rootless on both sides. Because of the heavy reliance on these impersonal mechanisms of communication that are susceptible to control, in the very worst case, this marvelous technology could be adapted to an authoritarian system. There is some fundamental truth certainly to fear in George Orwell's *1984*.

On the other hand, the rewards of doing this well are beyond the wildest dreams of anyone who has ever really cared about education at all, particularly for an American audience committed to American notions of individualism, democracy, and freedom. Consider that we now have the means to make our services accessible to everyone. Consider that instead of leveling a democratic system of higher education down to the lowest common denominator, we can gear it up so that everyone has the opportunity to be exposed to the highest manageable or obtainable levels of comprehension.

It is exciting to realize that this technology can be individualized so that people can participate in a common program and learn at their own speed. One of the nice things about computerized instruction, which is not my favorite medium of education, is that if certain students are lagging behind, they have a sensational way to catch up. You can also tape presentations, and because there is sight and sound, students do not just have to take notes. They can see it and hear it again.

The process can also be a universal, global mechanism. There could be something in that old saw about understanding breeding understanding.

The most important thing is that the power of the human mind, the human understanding, and the human energy, individually is so enhanced by this, it will make human beings much more intellectually powerful. If we can manage that well and turn it loose, just think of what services we could render, of what audience we are serving and what that can do to breed a post-Gutenberg civilization that could at its best be marvelous and at its worst, authoritarian and repulsive.

Accepting and Preparing for Change

Thirty or forty years ago, almost everything with which we are now familiar was new. Think about the world in which we are living. We may laugh at the notion of a computer printout where the paper self-destructs. But would we have thought that we would watch the space shuttle? It is blasting off again. It is normal. It is real. The jet is in our lifetime. Refrigeration is in the lifetimes of some of us. Frozen food is new. All of the electronic media are new. And so on.

In the ten years that I have been president of The Johns Hopkins Hospital I have seen a whole era come and go. Ten years ago we did not have any scanners and now we are getting rid of our scanners to put in NMR. Who knows? The whole business of invasive exploratory surgery may be ending.

That is the real world. That is not space science. That is not fiction. It is possible to do all these things, and everybody knows it. Some of us are worried about whether we should buy computers for our students. Don't worry. Within five years they will all come with computers and they may understand them better than the faculty does. That is a serious problem that must be dealt with immediately. Because the most serious problem is the post-Gutenberg university with a pre-Gutenberg faculty.

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